



Calhoun: The NPS Institutional Archive

Theses and Dissertations

Thesis Collection

1983-09

Experimental determination of the relative flow at the tip of a transonic axial compressor rotor

Cornell, David William

Monterey, California. Naval Postgraduate School

<http://hdl.handle.net/10945/19803>



Calhoun is a project of the Dudley Knox Library at NPS, furthering the precepts and goals of open government and government transparency. All information contained herein has been approved for release by the NPS Public Affairs Officer.

Dudley Knox Library / Naval Postgraduate School
411 Dyer Road / 1 University Circle
Monterey, California USA 93943

<http://www.nps.edu/library>

NAVAL POSTGRADUATE SCHOOL

Monterey, California



THESIS

EXPERIMENTAL DETERMINATION
OF THE RELATIVE FLOW AT THE TIP
OF A TRANSONIC AXIAL COMPRESSOR ROTOR

by

David William Cornell

September 1983

Thesis Advisor:

R. P. Shreeve

Approved for public release; distribution unlimited.

T215137

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS
BEFORE COMPLETING FORM

1. REPORT NUMBER		2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Experimental Determination of the Relative Flow at the Tip of a Transonic Axial Compressor Rotor			5. TYPE OF REPORT & PERIOD COVERED Engineer's Thesis September 1983
7. AUTHOR(s) David William Cornell			6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93943			8. CONTRACT OR GRANT NUMBER(s)
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93943			10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)			12. REPORT DATE September 1983
			13. NUMBER OF PAGES 223
			15. SECURITY CLASS. (of this report) Unclassified
			15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.			
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)			
18. SUPPLEMENTARY NOTES			
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) synchronized sampling, transonic compressor, acquisition software, real time, cascade			
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The goal in the present work was to examine the flow through the tip section of a transonic compressor rotor in three different ways; (1) using high response instrumentation in the compressor itself, (2) using a blow-down wind tunnel model of the relative flow at the rotor tip, and (3) using a new computer analysis code. Toward that goal, the present study reports the results of extensive measurements made in the			

20. ABSTRACT Continued

compressor and the software developed to acquire and reduce high response transducer data. Modifications made to the cascade and first results of applying S. Eidelman's Godunov code to the compressor rotor tip section are also included. It was concluded that a valid comparison of computed and measured results required both an improvement of the compressor in-flow and an extension of the analysis code to include three dimensional effects.

Approved for public release; distribution unlimited.

Experimental Determination
of the Relative Flow at the Tip
of a Transonic Axial Compressor Rotor

by

David William Cornell
Lieutenant Commander, United States Navy
B.S., United States Naval Academy, 1973
M.S., Naval Postgraduate School, 1983

Submitted in partial fulfillment of the
requirements for the degree of

AERONAUTICAL ENGINEER

from the

NAVAL POSTGRADUATE SCHOOL
September 1983

ABSTRACT

The goal in the present work was to examine the flow through the tip section of a transonic compressor rotor in three different ways; (1) using high response instrumentation in the compressor itself, (2) using a blow-down wind tunnel model of the relative flow at the rotor tip, and (3) using a new computer analysis code. Toward that goal, the present study reports the results of extensive measurements made in the compressor and software developed to acquire and reduce high response transducer data. Modifications made to the cascade and first results of applying S. Eidelman's Godunov code to the compressor rotor tip section are also included. It was concluded that a valid comparison of computed and measured results required both an improvement of the compressor in-flow and an extension of the analysis code to include three dimensional effects.

TABLE OF CONTENTS

I.	INTRODUCTION	10
II.	TRANSONIC COMPRESSOR	13
	A. COMPRESSOR DESCRIPTION	13
	B. INSTRUMENTATION OF THE COMPRESSOR	14
	C. SYNCHRONIZED SAMPLING	15
III.	ACQUISITION SOFTWARE	18
	A. ACQUISITION PROGRAM--WKAQN	18
	B. REDUCTION AND INTERPOLATION OF DATA	21
IV.	RESULTS AND DISCUSSION OF CASE-WALL PRESSURE	
	ACQUISITION	24
	A. TEST PROGRAMS AND RESULTS	24
	B. PRESSURE CONTOURS	26
	C. "BLADE" PRESSURE DISTRIBUTION	27
	D. COMPARISON WITH CODE RESULTS	28
V.	CONCLUSIONS AND RECOMMENDATIONS	31
	APPENDIX A: ACQUISITION SOFTWARE	67
	APPENDIX B: REDUCTION SOFTWARE	120
	APPENDIX C: TRANSONIC CASCADE	133
	APPENDIX D: DATA SET FOR 70% RPM, OPEN THROTTLE	163
	LIST OF REFERENCES	220
	INITIAL DISTRIBUTION LIST	223

LIST OF TABLES

I.	Transducer Identification	33
II.	Kulite CQL-080-25 Factory Specifications	34
III.	HP9830/21 MX Data Acquisition Port/Channel Assignments	35
IV.	Flow Conditions for Data Acquisition	36
V.	Flow Parameters for Contour Maps	37
VI.	Relative Conditions for Godunov Code Calculations .	38

LIST OF FIGURES

1.	Transonic Compressor Test Rig	39
2.	Transonic Compressor Stage	40
3.	Transducer Locations	41
4.	Transducer Signals	42
5.	Paced Data Acquisition System Components	43
6.	Pacer Input/Output Signals	44
7.	Spacing of Kulite Array and Evened Array	45
8.	Raw Kulite Data	46
9.	Repeated Data Acquisition	49
10.	Bi-stable Flow State	50
11.	Bi-stable Jumps	51
12.	Contour Map of Raw Data	52
13.	Contour Map of Coefficients (Not Smoothed)	53
14.	Smoothed Kulite Data	54
15.	Contour Map of 70% Speed, Open Throttle	58
16.	Contour Map of 70% Speed, Design Throttle	59
17.	Contour Map of 70% Speed, Near-Surge	60
18.	"Blade" Pressure Coefficients, 70%, Open	61
19.	"Blade" Pressure Coefficients, 70%, Design	62
20.	"Blade" Pressure Coefficients, 70%, Surge	63
21.	Contour Using Godunov Code	64
22.	"Blade" Pressure Comparison with Godunov Code	65
23.	Recommended Data Acquisition Technique	66

LIST OF ABBREVIATIONS

<u>Term</u>	<u>Description</u>
A/D	Analog-to-digital convertor
ARRAYA	Array for unsteady pressure data
DMA	Direct Memory Access
DVM	Digital voltmeter
OLCAL	Array to store on-line calibration and steady state data
PLL	Phase-Locked Loop
TCR	Transonic compressor
TPL	Turbopropulsion Laboratory
TTL	Transistor-transistor logic

ACKNOWLEDGMENT

A study like this cannot be accomplished without the expertise and help of many people. I'd like to thank Glen Middleton and Don Harvey for machining the cascade parts, John Morris and Kelly Harris for keeping the compressor running, and Alan McGuire, who drew so many of the engineering drawings and helped me with most of the remaining.

Jim Hammer spent many hours explaining to me details and procedures, without which, I would still be wallowing in interfaces. His influence has been the stabilizing influence in a project with alot of turnover of personnel.

A special thanks is offered to Friedrich Neuhoff who helped me with the computer and to interpret the results as well as keeping me enthusiastic about my research.

Thanks to Professor Raymond Shreeve for giving me the slack-in-the reins to pursue the problem in my own way and for having the faith in me that the pursuit would yield productive results.

Finally, I'd like to thank my family for having to put up with fatherless evenings and weekends, and for supporting me throughout the project.

I. INTRODUCTION

The goal in the present work was to examine the flow through the tip section of a transonic compressor rotor in three different ways; (1) using high response instrumentation in the compressor itself, (2) using a blow-down wind tunnel model of the relative flow at the rotor tip, and (3) using a new computer analysis code. Toward that goal, the present study reports the results of extensive measurements made in the compressor and the software developed to acquire and reduce high response transducer data. Modifications made to the cascade and first results of applying S. Eidelman's Godunov code to the compressor rotor tip section are also included.

The work is part of the Airbreathing Propulsion Program sponsored by Naval Air Systems Command, Code 310. The Naval Postgraduate School (NPS) program has the objectives of (1) assessing transonic design and analysis methods, and (2) understanding three dimensional and unsteady flow. Experiments in the program make use of a single-stage transonic compressor and a blow-down transonic cascade model, both located at the NPS Turbopropulsion Laboratory (TPL).

In the present study, case wall pressures were obtained in the rotor reference frame by timing of the acquisition of data from fast response transducers, previously called

"synchronized sampling." [Ref. 1] Using this approach, steady flow with respect to the rotor can be investigated very well and its unsteadiness examined to some degree. The data was reduced to pressure coefficients and plotted on contours to enable the behavior of the flow field to be visualized. Data were obtained at compressor speeds from 50% to 70% of the design speed (30,460 RPM), each at three throttle settings. An initial analysis of the data is included herein.

The two dimensional transonic cascade model was designed and built several years ago. [Ref. 2] [Ref. 3] As part of the present work, a throttle valve was designed to adjust the back pressure of the flow through the cascade test section in order to produce conditions found in the compressor. Additionally, a plexiglass window was designed and built to enable Schlieren photography of the flow in the test section.

A two dimensional inviscid code, involving a solution of the Euler equations based on the Godunov method, was developed recently by S. Eidelman. [Ref. 4] The code was applied to the tip section flow and first results are presented.

The following section describes in detail the transonic compressor facility including the transonic compressor (TCR), instrumentation, and data acquisition system. Section III discusses the use of the acquisition software, reduction software, and interpolation schemes used in obtaining

pressure contours. The results of the case wall pressure investigation is discussed in Section IV with results of numerical modeling. Section V presents conclusions and recommendations for further steps necessary to complete this study.

The major contribution in the present work is considered to be the development of the software to successfully acquire, reduce, and present data from the compressor, and the data acquired. Appendix A provides a detailed description, flow diagram and listing of the primary FORTRAN programs used in acquisition of case wall pressure data. Appendix B contains description of the programs used in data reduction and contour plotting, the program listings and flow diagrams.

The modifications made to the transonic cascade model are presented in Appendix C, including the drawings of the new throttle valve and the window assembly.

II. TRANSONIC COMPRESSOR

A. COMPRESSOR DESCRIPTION

The transonic compressor is a single stage axial fan driven by a 1250 HP Allis-Chalmers multi-stage axial compressor air supply. The drive air is routed to a dual axial turbine which is connected to the transonic compressor drive shaft. (See Fig. 1) Air can be regulated to a balance piston housing with a labyrinth seal to adjust the thrust load on the compressor drive shaft.

The compressor is designed to operate at an RPM of 30460 and a tip relative mach number of 1.5. A throttle, filter, and flow nozzle in the inlet duct allows the flow rate to be adjusted and metered. At open throttle and design speed, the referred flow rate is 15.7 pounds per second with a relative flow angle at the tip of 65° . The design pressure ratio 1.5. [Ref. 5]

The rotor consists of an integral blade and disk assembly of machined aluminum. The rotor has eighteen single-circular-arc blades. The diameter of the case wall is 11.0 inches and the hub to tip ratio is 0.5 at the rotor face. [Ref. 1] The stator is free to rotate on flexures on which strain gages are mounted to measure the torque. A flow straightener is attached to the stator assembly to remove any remaining swirl from the flow so that stator and

rotor torques are balanced. The flow is exhausted through a radial diffuser to the atmosphere.

B. INSTRUMENTATION OF THE COMPRESSOR

Steady state data are acquired from fixed Kiel pressure and stagnation temperature probes mounted behind the stage. (See Fig. 2) Pressures and temperatures are also obtained from the flow nozzle installed upstream. Flow rate is obtained from prior calibration.

Pneumatic taps (23) are mounted in the case wall oriented axially from in front of the rotor to behind the stator. Twelve of the taps are colocated axially with Kulite CQL-080-25 fast-response semiconductor transducers. (See Fig. 3 and Table 1) The pneumatic pressures are read using a Scanivalve and an HG-78K Scanivalve Controller (U.S. Patent 4,383,300 [Ref. 6]), directed by acquisition software.

The Kulite transducers are spaced from 1.375 inches in front of the rotor to 0.375 inches behind the rotor. They are mounted in different circumferential positions to allow close axial spacing of relatively large diameter transducers mounts. (See Fig. 3) The manufacturer's specifications for the Kulite transducers are listed in Table II. The Kulites output a bridge voltage proportional to the difference of the pressure measured on the front face, which is flush with the compressor wall, and a reference pressure applied to the back of a diaphragm. (See Fig. 4) From Table II, it can be

seen that the transducers have a natural frequency of 125 kHz allowing sampling rates of 25kHz without significant distortion. [Ref. 7]

The output voltage is routed to both a digital voltmeter (DVM) and to an analog-to-digital convertor. The HP-3455A DVM is used at a data sampling rate of 5Hz while the blade passing frequency is up to 9438 Hz at 100% RPM. Therefore, the DVM effectively measures the time averaged pressure from the Kulites. [Ref. 8]

The HP-5610 16-channel A/D converter operates at a maximum rate of 100,000 samples per second with an aperture window of 50 nanoseconds. [Ref. 9] Since the maximum sampling rate required for unsteady measurements is 508 samples per second at 30460 RPM (100%), the present A/D system is more than sufficient.

The A/D requires an input voltage between plus and minus one volt and outputs a ten bit digital word to the computer. This means that the A/D can only discern increments of 0.002 volts. The Kulite output with normal excitation is 0.0001 volts per inch of water differential pressure and thus the transducer voltage is boosted by Datel M201 amplifiers to obtain adequate resolution using the A/D converter.

C. SYNCHRONIZED SAMPLING

In order to obtain pressure data from known positions in the rotor frame, a controlled sampling procedure is used.

Samples are converted when the rotor is at the same relative location with respect to the separate transducers. This method of acquisition, by "Synchronized Sampling" [Ref. 1], is triggered by a signal produced at the compressor drive shaft. (Fig. 5) The trigger signal is produced by a light source passed through a hole in a timing disk which is mounted on the turbine end of the compressor drive shaft. (See Fig. 5) A photo diode senses the light and sends a pulse to the acquisition system on every revolution of the shaft. In addition, a second set of eighteen holes in the timing disk allows a one-per-blade signal to be generated by a second photo diode.

The two pulses are sent to a "Pacer" unit, (U.S. Patent 4,181,962 [Ref. 10]) where a wave shaper converts the signals to square waves, halves in frequency, and inputs to a Phased-Lock Loop (PLL) circuit. The PLL develops a signal of the same shape as the input but with a frequency 256 times as large. The result is a continuous sequence of 128 timing pulses per blade passage as shown in Figure 6.

A counting circuit in the Pacer counts the number of timing pulses that have occurred since the last one-per-rev signal which is used as a reset pulse and compares it to the delay word sent by the computer subroutine "WKPAC." When the two are the same, the Pacer sends out an encode pulse to the A/D convertor. A complete description of the pacer in



the current configuration and the software drivers to control it are given by McCarville. [Ref. 11]

The A/D converter is triggered by the encode pulse to convert the voltage sent by the Kulite transducer (via the amplifiers) to a ten bit digital value and pass it on to the computer.

The Hewlett-Packard 21MX Computer is used to control the entire acquisition process. The system is equivalent to an HP-1000 series machine, with 178 user programmable microinstructions and a 320 nanosecond ROM clock. [Ref. 12] A DMA feature allows data transfer to memory at a 100 kHz rate. [Ref. 13] Data storage is provided by an HP-7906 Disc Drive with a capability of storing 20.2 million 16-bit words on HP-12940A Disc Cartridges. [Ref. 14]

III. ACQUISITION SOFTWARE

A. ACQUISITION PROGRAM--WKAQN

Case wall pressure data were acquired using the FORTRAN program "WKAQN." The program was used to perform an on-line calibration of the Kulite transducers, acquire synchronized-sampled data of all twelve Kulites using the pacer, plot the raw data, perform a second on-line calibration, and store all the pressure and calibration data on the disk for future reduction. The program flowchart and listing can be found in Appendix A. A complete description of the use of the program can be found in NPS Technical Note 83-01. [Ref. 15]

The basic program is divided into sections so that the user may elect to omit portions of the procedure or modify specific routines. After the initial dimension statements and identification inputs, the on-line calibration is initiated.

The calibration of Kulite differential transducers is necessary to relate the voltage recorded by the computer to the precise value of the pressure sensed. Since the transducer response changes with its temperature, the calibration should be performed using the subroutine "WKOLC." The routine systematically calls the proper interface subroutines to retrieve the proper sequence of voltage data from the

different instruments. The functions "SCANR" and "ACQN" used in WKOLC are taken from R. N. Geopfarth. [Ref. 6]

The transducer operates by sensing the difference between a pneumatic reference pressure applied to the back side of a diaphragm, and the unknown pressure of interest appearing on the front side. The differential pressure causes a strain in the silicon diaphragm which is converted to an electrical signal using a strain gauge bridge circuit. The bridge output is sent to the A/D convertor or the digital voltmeter (DVM). If the pressure of interest was known, it could be plotted against the voltage recorded. This has been done with near linear results by Paige. [Ref. 7] In the transonic compressor, the pneumatic taps located at the same axial location as the Kulites can be used to measure the pneumatically averaged pressure at that case-wall location. It is an average because the frequency of blade passing does not allow enough time for the volume in the pneumatic lines and Scanivalve unit to adjust to the changes in pressure. To read the corresponding average pressures from the Kulites, the signals are sent to the DVM which has an integration period of .0166 seconds. This is much longer than the period of the rotor represented by a blade passing frequency of 9438 hz at design speed. Therefore the DVM will provide an average Kulite signal corresponding to an average pressure at that location. Since the average Kulite and corresponding pneumatic pressures are

the same, the absolute level of the Kulite transducer output can be established by equating the two.

For each Kulite transducer, a reference pressure is set and the Kulite data are read through the DVM and stored in array "OLCAL." A different reference pressure is then set and the process is repeated for up to six reference pressures. Six points for each Kulite then can be plotted on a voltage versus pressure plot. A linear curve fit is called in subroutine "CURFT" which uses the least-squares method of the approximation. The resulting slopes and intercepts from the equation generated are also stored in the original data array.

In addition to on-line calibration data, routine WKOLC also measures those data which do not need to be repeated for each acquisition loop. For example, since the flow conditions through the compressor should remain constant during wall-Kulite acquisition, the pressures and temperatures from steady-state instrumentation which are needed for reference conditions are read here. The data read during the first on-line calibration are read into the first row of array "OLCAL."

The acquisition loop is started. The program uses the subroutine "WKPAC" to gather the pressure data for one Kulite transducer through synchronized sampling across two blade passages ("one blade pair"). Each of 256 circumferential locations are sampled N-times. This volume of data is

too large to store, and therefore the average, maximum, minimum, and root-mean-square values of the N samples are calculated at each of the 256 locations and stored in the data array, "ARRAYA."

In order to verify the success of the acquisition, the average values are plotted using the "son" program WKPLT. A description of the father-son programming is available in the Hewlett-Packard RTE-IVB Programmer's Reference Manual. [Ref. 16]

When the last Kulite has been sampled, a second on-line calibration is called. The second calibration is compared to the first to ensure that the calibration was stable during the acquisition process, and that the values recorded are therefore accurate.

The data are stored in files on the disk of the system for later reduction.

B. REDUCTION AND INTERPOLATION OF DATA

For the tests reported herein, the voltage data acquired through the A/D converter were transferred to the central NPS IBM 3033AP Computer System in order to take advantage of the library of interpolation and graphing routines.

The Kulite data were reduced to pressure coefficients using the program WKCONCP. Since the Kulites are not evenly spaced axially, and since the values in the data array would be weighted evenly in a contour routine, a linear interpolation was made of the raw data to reduce distortion. (Fig.

3) The scheme generating this 16 x 256 array can be found in Appendix B.

Data smoothing was accomplished using a subroutine "ICSMOU" from the computer's technical library. [Ref. 17] The routine uses a cubic spline approximation to compare present with succeeding data points. If the point falls outside of a convergence criterion, the point is thrown out and a new point is generated. The result is a smoothed data set with spurious spikes removed.

Pressure coefficients were generated using the relationship:

$$C_p = (P - P_{s9}) / Q_{s9} \quad (3-1)$$

where P is the Kulite pressure, P_{s9} is a freestream reference pressure, and Q_{s9} is a freestream dynamic pressure. Since an accelerating freestream exists into the rotor of the compressor, a reference condition was established by extrapolating undisturbed measured static (wall) pressure values in the inlet duct to the rotor leading edge by curve fitting. The detail of this procedure can be found in Appendix B. The dynamic reference pressure is obtained from perfect gas relationships and measured flow quantities of total pressure, static pressure, and total temperature. The equations are also given in Appendix B.

The pressure coefficients can be plotted as a three dimensional surface, or, as has been done here, as a contour map. The FORTRAN program WKCONPLT was used to read the

coefficient data and generate the contour vectors using a series of subroutines from an integrated software graphics library called "DISSPLA." [Ref. 18] This particular contour package was chosen since it offered several different smoothing techniques. The program listing is given in Appendix B.

IV. RESULTS AND DISCUSSION OF CASE-WALL PRESSURE ACQUISITION

A. TEST PROGRAM AND RESULTS

Tests were conducted first to verify the data acquisition procedures. Raw data were acquired using the program WKAQN from each Kulite transducer individually and plotted using program WKPLT to observe the waveform of the ensemble-average data. If the data appeared smooth, it was saved and the program sequenced to the next Kulite. If, however, the data contained spurious spikes, the measurement was repeated until a relatively smooth waveform was obtained. Figure 8 shows examples of recorded data.

The reliability of the acquisition procedure was of first concern, and was tested. The steady state conditions were first verified by use of the FORTRAN program TXC00. [Ref. 19] The reliability of the acquisition was demonstrated by repeating measurements from the same Kulite at the same compressor run conditions. Figure 9 shows how precisely this data was repeatable. Two different Kulites were recorded, then both were repeated with near identical results.

After repeating what was apparently noisy data at one throttled condition, it was observed that the flow fluctuated between two quasi-steady states. Figure 10 shows the repeated measurements of the ensembled-averaged outputs at

the same compressor flow conditions (average) for Kulite 9.5. It can be seen that although the measurements were repeated eight times, the flow appeared to be in one or the other of two distinct states or in the process of transitioning between them. The phenomenon was observed as a result of the acquisition process which could measure from 1 to 99 data samples at each blade-to-blade location, and store the average before moving on to the next location. When the flow jumped to the alternate state, the next and subsequent data points (the average values of the number selected) showed the change. Figure 11 shows several jumps with the envelope of the two states superimposed. The jumps were observed not following any obvious pattern which suggested that the fluctuation was not periodical, though a more complete investigation is warranted.

The variation between blade pairs was also examined. A series of measurements was taken at a fixed operating condition, changing only the counts sent to the pacer. This allowed a sequential sampling of the blade pairs one to nine. It was observed that significant variations occurred from one blade passage to the next. The blade pairs with the most similar distributions were 4, 5, and 6, and these were therefore selected for the acquisition of complete data at varying speeds and flow rates.

Complete sets of unsteady data were acquired and stored for the fifteen run conditions listed in Table IV. The

conditions chosen representatively cover the compressor map over a speed range of 50-70% of design RPM. Only the data obtained at 70% speed are presented and discussed in the following section. The data are stored on disc files named by a scheme described in Appendix A.2 and A.3.

B. PRESSURE CONTOURS

Figure 12 shows the voltage output of each transducer for an open throttle at 70% RPM. The data were interpolated to even the spacing between the rows of the array, and contours were generated as shown in Figure 13. It can be seen that very large distortions exist in the contour map, most noticeably at the blades, and considerable noise.

Various smoothing techniques were attempted to remove the noise. The smoothing routines available to the DISSPLA graphics package were chosen due to the ease of usage. Rational splines, cubic splines, and polynomial interpolations were tried. Smoothing was tried in the axial columns alone, the circumferential rows, and in both directions. It was found that very little difference resulted from the use of different methods, but that more complicated smoothing techniques distorted the data so as to no longer represent the flow. Therefore, a cubic spline interpolation in the circumferential direction alone was chosen for the contour maps. Figure 14 shows the interpolated data after circumferential smoothing. Figures 15, 16 and 17 show the contours obtained for the data at 70% speed at open throttle,

design, and highly throttled conditions. The flow parameters used for calculation of the coefficients are given in Table V.

It is clear from Figures 15, 16, and 17, that the contours are not correct in the neighborhood of the blades, as was found similarly by Simmons. [Ref. 5] This has to do with rapid changes across the blades in the circumferential direction and sparse spacing of lines in the axial direction. The contours are interpolated across the blades in the axial direction, when in fact almost discontinuous changes occur everywhere along the blade.

C. "BLADE" PRESSURE DISTRIBUTIONS

Figure 18 shows the distribution of the maximum and minimum values of the pressure coefficient at each Kulite location. The location of the blade is also shown, and over this length, the maximum and minimum values occur at the blade pressure and suction surfaces respectively. The figure clearly illustrates the propagation of the unsteady effects forward of the leading edge. It is noted that values of C_p greater than zero occur far upstream of the blades because the undisturbed upstream pressure decreases to the rotor face as a result of the contraction in the flow path.

The effect of the throttle changes can be seen in the three figures. As the throttle is closed, the pressure rise

increases and the blade force inferred from the area between the maximum and minimum pressure lines, also increases.

D. COMPARISON WITH CODE RESULTS

Attempts were made to obtain a comparison of the measured pressure contours and "blade" pressure distribution with the results of numerical calculations using the Godunov code described in Reference 4. The attempts were unsuccessful, however the difficulties inherent in trying to obtain a valid comparison were identified.

The code was run twice by Dr. S. Eidelman, for the conditions at open throttle and 70% speed. The first run, with the air inlet angle specified to be $\beta_1=70^\circ$, did not converge to a steady solution in 4000 iterations. Other similar cases had been demonstrated to converge in less than 2000 iterations. The incidence angle of 70° was inferred from probe measurements of inlet axial velocity near the case wall, and the wheel speed. While the air angle appeared to be impossibly large for the blade stagger angle ($\gamma \approx 60^\circ$), the probe measurements had been carefully verified.

The second run was made using conditions consistent with those used in computing pressure contours. These conditions are given in Table VI. It can be seen that by calculating an "undisturbed" static pressure at the rotor leading edge and using a measured stagnation pressure upstream, a larger value of axial Mach number and correspondingly smaller value

of air incidence angle ($\beta_1=62.5^\circ$) were obtained. The results running the code with the conditions shown in Table VI are shown in Figure 21 and Figure 22. Clearly, from the blade surface distributions shown in Figure 22, there is no similarity at all in the results for the blade surface pressure. It is noted however that the code converged successfully and Figure 21 is considered to display a valid solution of the Euler Equations for the 2D relative transonic flow through the rotor tip section, with the boundary conditions specified in Table VI.

There are two considerations which make a comparison between measurement and computational results premature. First, the code is two-dimensional and can not accommodate streamline contraction, even if that contraction could be specified from measurements. It is noted that the results of the code are extremely sensitive to small changes in geometry and boundary conditions. Hence it will be sensitive also to changes in streamline contraction.

Second, the flow through the present rotor is anomalous. The incidence angles at the tip inferred from probe measurements are too high to be practical at transonic Mach numbers by usual cascade criteria. If the rotor is indeed operating in a flow approaching from such an extreme angle, then three dimensional effects must be present at the tip which would invalidate the comparison being attempted.

Clearly, a closer examination and possibly a correction of the flow into the tip section are required.

V. CONCLUSIONS AND RECOMMENDATIONS

1. The acquisition of Kulite data was verified to be repeatable but the results were clearly dependent on the blade pair selected. The number of samples averaged was shown not to be significant.
2. Smoothing of Kulite data to remove spikes before plotting as contours was shown to be effective, but more complicated routines distorted the measurements.
3. A special contour routine is needed to account for the physical boundary of the blades and uneven spacing of the sensors. Although some flow may cross the boundary at the blade tip, the gradients across the blade are close to discontinuities. Thus the contour routine must not allow interpolation across the blade boundary. It is recommended that data be taken in the future as shown in Figure 23. Using appropriate delays, data can be acquired in a format which can be input directly into contour plotting routines used for the code contours.
4. The data was transferred to the IBM 3033 by hand which was time consuming and prone to error. It is recommended that the contour routine be generated on the HP-21MX computer or that a tape interface be established to transfer the data to the IBM computer.

5. The computational method does not account for stream tube contraction and therefore could not properly represent the flow in the compressor. A more valid comparison can be made when streamline contraction and radius change effects are included in the code.
6. The transonic cascade, which more closely duplicates the code model, needs to be completed. Specific recommendations were presented in Appendix C.
7. The results indicated the direction needed in future investigations. The compressor runs were here limited to a 70% design speed due to the unusually high incidence angle indicated to be present on the rotor blade. The high incidence caused undesirably high loading on the blades and therefore, higher speeds were not attempted. A very steep contraction over the nose ("spinner") of the rotor to the rotor inlet may be causing a deficit in the axial velocity near the tip. If further examination shows this to be true, a redesigned inlet should be considered to correct the flow profile into the rotor blades.

Also, the bi-stable conditions encountered at throttled conditions should be investigated. It is uncertain whether the two states are created by a moving shock or transient stall condition. However, the inlet flow field should be carefully examined first to ensure that the blading is not being forced to operate in an unstable regime.

TABLE I
Transducer Identification

<u>Pneumatic Port</u>	<u>Kulite Number</u>	<u>A/D Chnl</u>	<u>Axial Location</u>
S1	-	-	Ref
S2	-	-	1.00
S3	-	-	2.00
S4	-	-	3.00
S5	-	-	3.50
S6	K6	2	4.00
S7	K7	3	4.50
S7.5	K7.5	4	4.81
S8	K8	5	5.00
S8.5	K8.5	6	5.18
S9	K9	7	5.37
S9.5	K9.5	8	5.56
S10	K10	9	5.75
S10.5	K10.5	10	5.93
S11	K11	11	6.12
S11.5	-	-	6.31
S12	K12	12	6.50
S13	K13	13	7.00

TABLE II
Kulite CQL-080-25 FACTORY SPECIFICATIONS
[Ref. 7]

Rated Pressure -----	25 psi
Max. Pressure -----	50 psi
Nominal Output (Rated Pressure) -----	75 mV
Bridge Excitation Voltage -----	5 V (7.5V max)
Bridge Impedence -----	750 Ω
Zero Balance -----	$\pm 3\%$ Full Scale
Combined Non-Linearity and Hysteresis -----	$\pm 1.0\%$ Full Scale
Repeatability -----	0.5%
Compensated Temperature Range -----	25-80° C
Change of Sensitivity with Temperature ----	$\pm 2.5\%$ / 100° F
Change of no-load Output with Temperature -	$\pm 2\%$ / 100° F
Natural Frequency -----	125 KHz
g-Sensitivity -----	Perpendicular: 0.0003%FS/g
	Transverse: 0.00006%FS/g
Resolution -----	INFINITE

TABLE III

HP9830/21 MX Data Acquisition

Port/Channel Assignments

S.V. #1	S.V. #4	ch	SCANNER #1	ch	SCANNER #2	ch	SCANNER #2
1 (Tare) PA-PA	(Tare) PA-PA	0	Adv. S.V. #1	0	Ttl -Turb Noz	40	K6 DC Level
2 (Scale) Pcol-PA	(Scale) Pcal-PA	1	" S.V. 2	1	Tt Turb In	41	K7 "
3 Flow Noz P1-PA	Probe #1 P 1-PA	2	" S.V. 3	2	Tt Turb Out(L)	42	K7.5 "
4 Flow Noz P2-PA	Probe #1 P 23-PA	3	" S.V. 4	3	Tt Turb Out(R)	43	K8 "
5 Inlet Ptoo-PA	Probe #1 P 4-PA	4	" S.V. 5	4	TD Comp Noz	44	K8.5 "
6 Tip S 1 -PA	Probe #2 P 1-PA	5	Reset S.V. #1	5	Tw Comp Noz	45	K9 "
7 " S 2 -PA	Probe #2 P 23-PA	6	" S.V. 2	6	Tto Comp In	46	K9.5 "
8 " S 3 -PA	Probe #2 P 4-PA	7	" S.V. 3	7	TtA4 Out	47	K10 - "
9 " S 4 -PA	Inlet P t-PA	8	" S.V. 4	8	TtBA Out	48	K10.5 - "
10 " S 5 -PA	Inlet P s-PA	9	" S.V. 5	9	TtCA Out	49	K11 - "
11 " S 6 -PA	Rake C 7-PA	10	P-ducers S.V. #1	10	Tcell	50	K12 - "
12 " S 7 -PA	" A 1-PA	11	" S.V. 2	11	"	51	K13 - "
13 " S 7.5-PA	" B 1-PA	12	" S.V. 3	12	ΔT - Turb(L)	52	Probe "A" - "
14 " S 8 -PA	" C 1-PA	13	" S.V. 4	13	ΔT - Turb(R)	53	Probe "B" - "
15 " S 8.5-PA	" A 2-PA	14	" S.V. 5	14	ΔT CompA4	54	
16 " S 9 -PA	" B 2-PA	15	RPM - AC	15	ΔT CompB4	55	
17 " S 9.5-PA	" C 2-PA	16	" - TTR	16	ΔT CompC4	56	
18 " S10 -PA	" A 3-PA	17	" - TCR	17	"	57	
19 " S10.5-PA	" B 3-PA	18	" - TTR	18	Tin Ref Probe	58	
20 " S11 -PA	" C 3-PA	19	1/Blade - TCR	19	ΔT Rotor Out	59	
21 " S11.5-PA	" A 4-PA	20		20		60	
22 " S12 -PA	" B 4-PA	21		21		61	
23 " S13 -PA	" C 4-PA	22		22		62	
24 " S14 -PA	" A 5-PA	23		23		63	
25 " S15 -PA	" B 5-PA	24		24		64	
26 " S16 -PA	" C 5-PA	25	P Baro in Hg	25		65	
27 " S17 -PA	" A 6-PA	26	Comp Noz P1	26		66	
28 " S18 -PA	" B 6-PA	27	Comp Noz ΔP	27		67	
29 " S19 -PA	" C 6-PA	28	Turb Noz P1	28		68	
30 Hub H 1 -PA	" A 7-PA	29	Turb Noz ΔP	29		69	
31 " H 2 -PA	Diff D S1-PA	30	Probe #1 Pos	30		70	
32 " H 3 -PA	" D S2-PA	31	Probe #1 Yaw	31		71	
33 " H 4 -PA	" D S3-PA	32	Probe #2 Pos	32		72	
34 " H 5 -PA	" D S4-PA	33	Probe #2 Yaw	33		73	
35 " H 6 -PA	" D S5-PA	34	Probe KA Pos	34		74	
36 " H 7 -PA	" -PA	35	Probe KA Yaw	35		75	
37 " H 8 -PA	" -PA	36	Probe KB Pos	36		76	
38 " H 9 -PA	Turb P t1-PA	37	Probe KB Yaw	37		77	
39 " H10 -PA	" P1(L)-PA	38	Comp Torque	38		78	
40 Diff Exit Dt1 -PA	" P1(R)-PA	39	"R" Ref Press	39		79	
41 " Dt2 -PA	" P2(L)-PA						
42 " Dt3 -PA	" P2(R)-PA						
43 " Dt4 -PA	" P3(L)-PA						
44 " Dt5 -PA	" P3(R)-PA						
45 " Dt6 -PA	" Pt3(L)-PA						
46 " Dt7 -PA	" Pt3(R)-PA						
47 " Dt8 -PA	" Brg Lube -PA						
48 " Dt9 -PA	C. Thrust Bal -PA						

TPL 4/01/81

JH

TABLE IV
Flow Conditions for Data Acquisition

<u>Test Condition</u>	<u>RPM</u>	<u>Referred Flow Rate</u>	<u>PR</u>
Open Throttle			
50%	15250	10.5	1.114
60%	18250	12.4	1.168
63%	19150	13.1	1.187
67%	20190	13.8	1.210
70%	21216	14.6	1.235
Design Throttle			
50%	15160	9.9	1.124
60%	18255	12.1	1.186
63%	19200	12.7	1.209
67%	20160	13.4	1.233
70%	21100	14.1	1.262
Near Surge Throttle			
50%	15330	9.2	1.148
60%	18200	10.7	1.222
63%	19200	11.3	1.250
67%	20170	12.0	1.280
70%	21130	12.7	1.310

TABLE V

Flow Parameters for Contour Maps

Run 145	70% Open Throttle
PT	389.74 in. H ₂ O
TT	292.3 °K
Ps9	331.59 in. H ₂ O
U	313.35 in. H ₂ O
MW	1.0536
Qs9	258.05 in. H ₂ O
Ms9	0.4857
Run 143	70% Design Throttle
PT	343.91 in. H ₂ O
TT	294.21 °K
Ps9	335.34 in. H ₂ O
U	308.67 in. H ₂ O
MW	1.0335
Qs9	251.10 in. H ₂ O
Ms9	0.4661
Run 144	70% Near Surge Throttle
PT	344.16 in. H ₂ O
TT	294.23 °K
Ps9	306.14 in. H ₂ O
U	309.11 in. H ₂ O
MW	1.0011
Qs9	215.56 in. H ₂ O
Ms9	0.4117

TABLE VI

Relative Conditions for Godunov Code Calculations

* $P_2 = 0.9623$ atmos. (391.49 in. H_2O)

$P_1 = 0.815$ atmos. (331.59 in. H_2O)

$T_1 = 284.5$ °K

* $M_1 = 1.054$

* $\beta_1 = 62.5^\circ$

* $P_{t1} = 1.6448$ atmos.

* $T_{t1} = 347.7$ °K

* Denotes boundary conditions required to be input.

COMPRESSOR TEST RIG

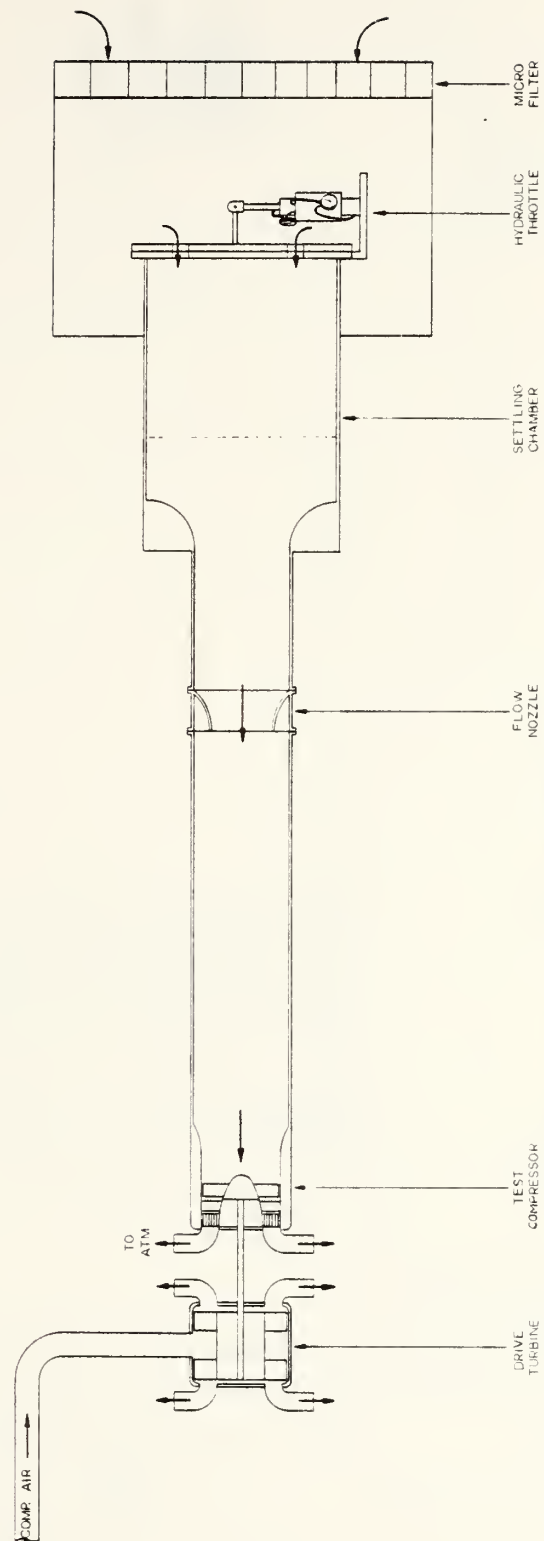


Figure 1 Transonic Compressor Test Rig

ATMOSPHERE

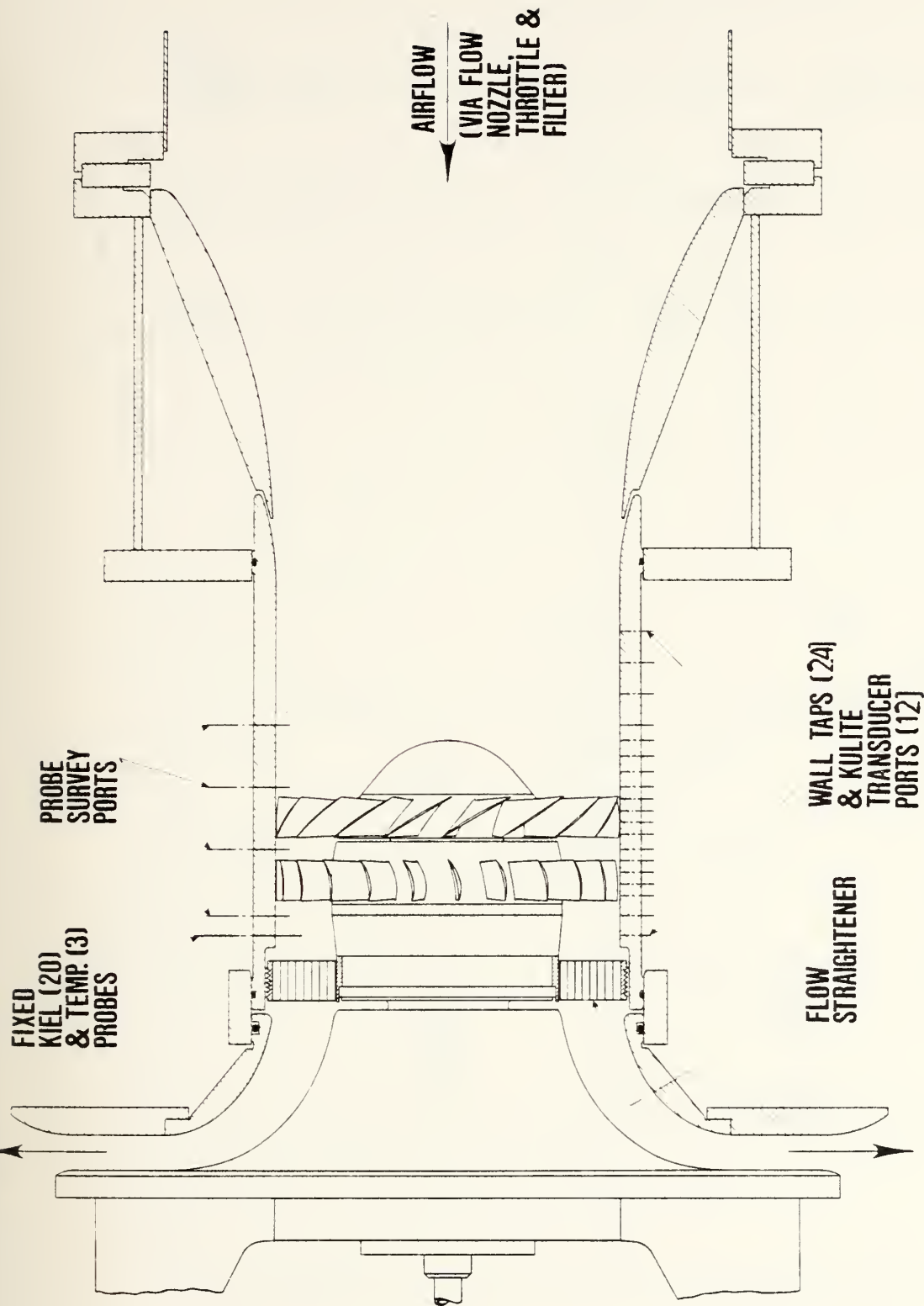


Figure 2 Transonic Compressor Stage

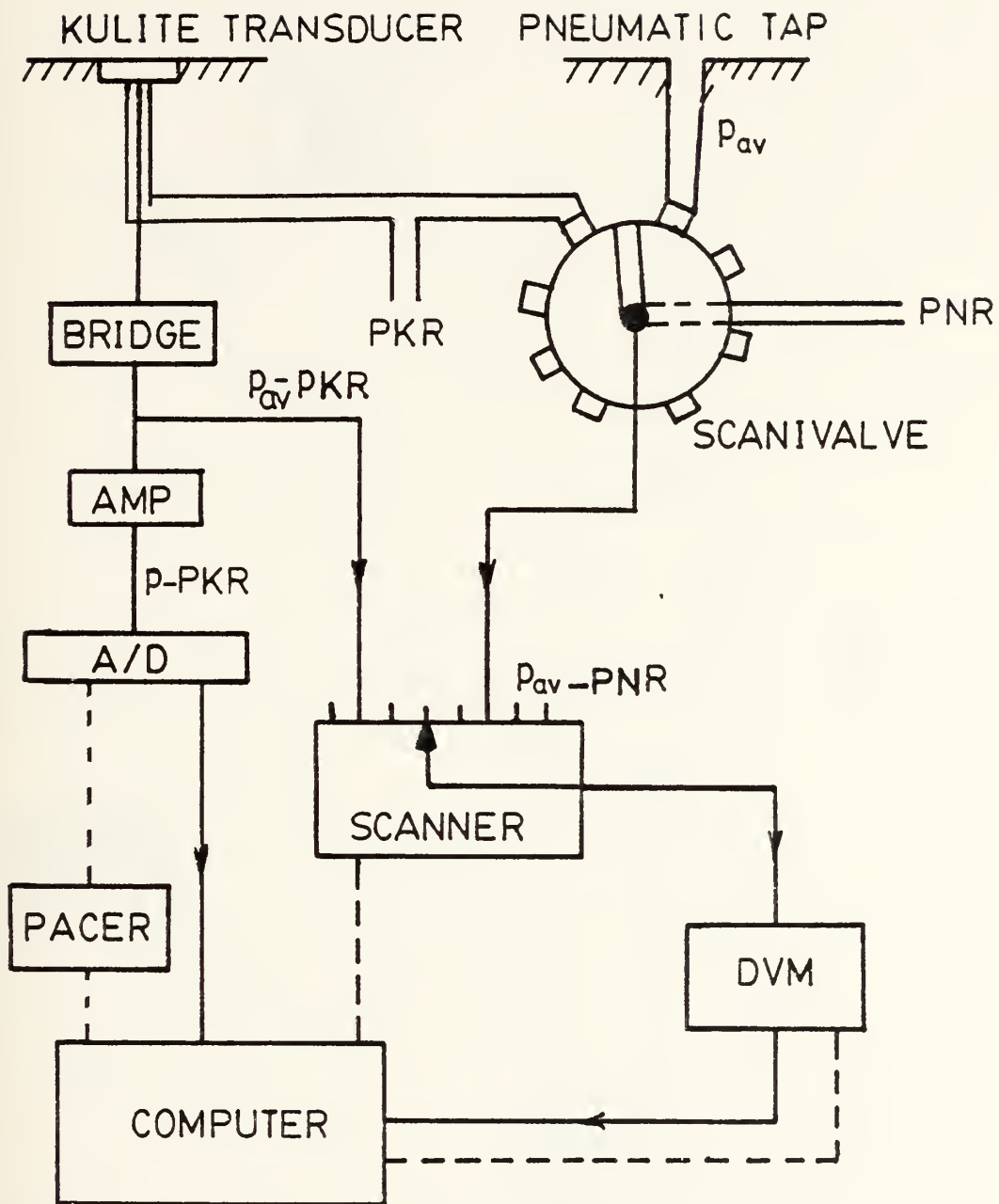


Figure 4 Transducer Signals

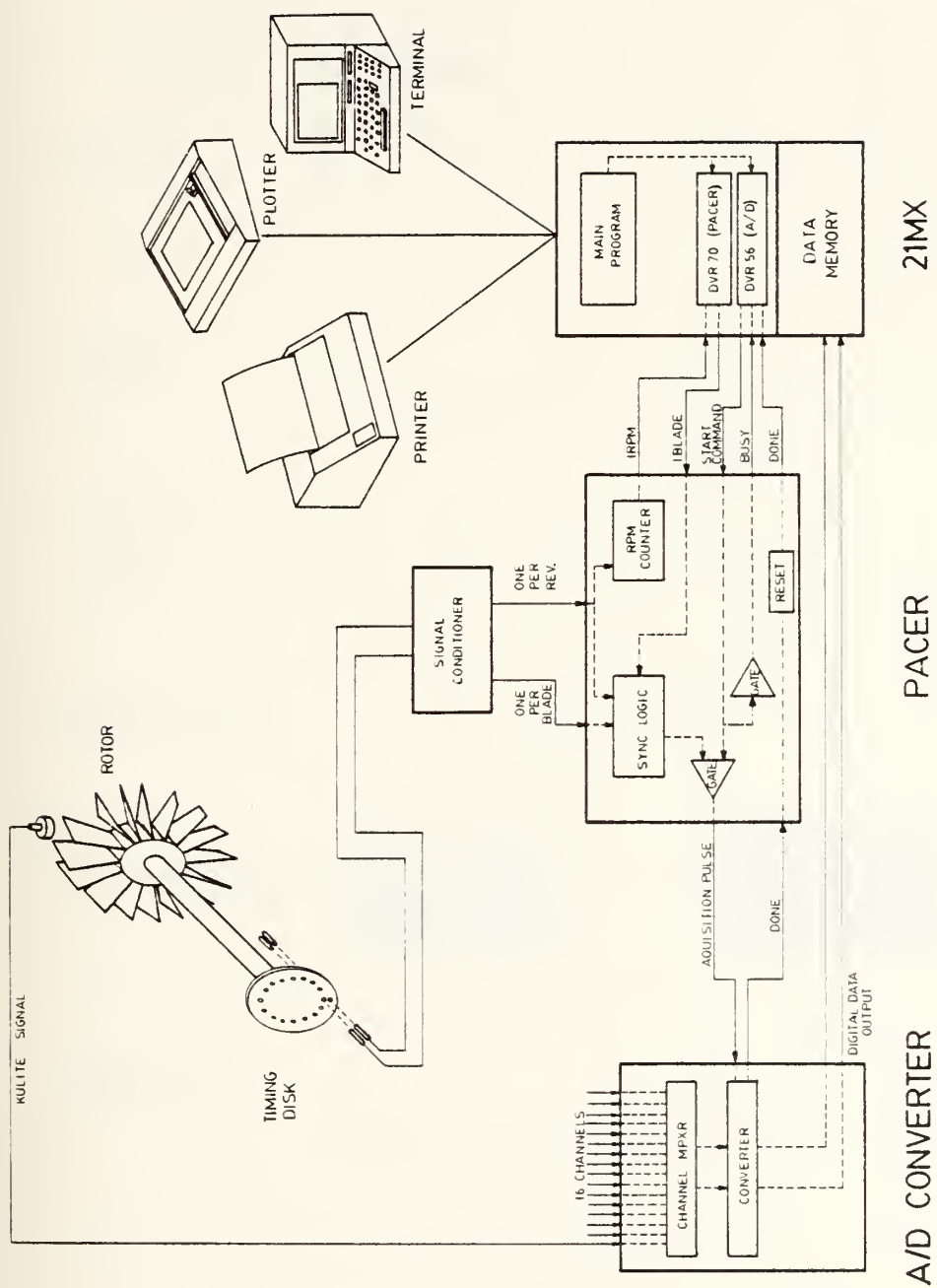


Figure 5 Paced Data Acquisition System Components

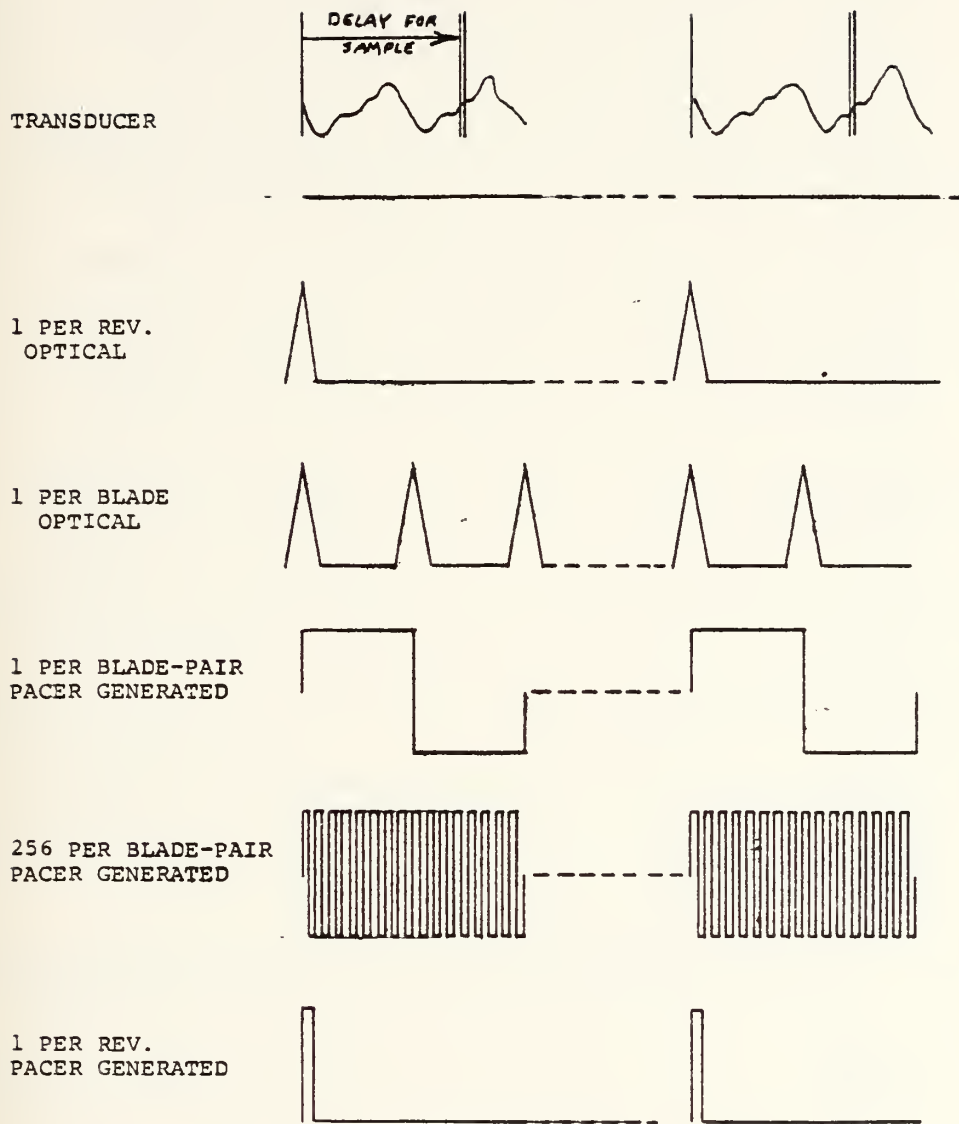


Figure 6 Pacer Input/Output Signals

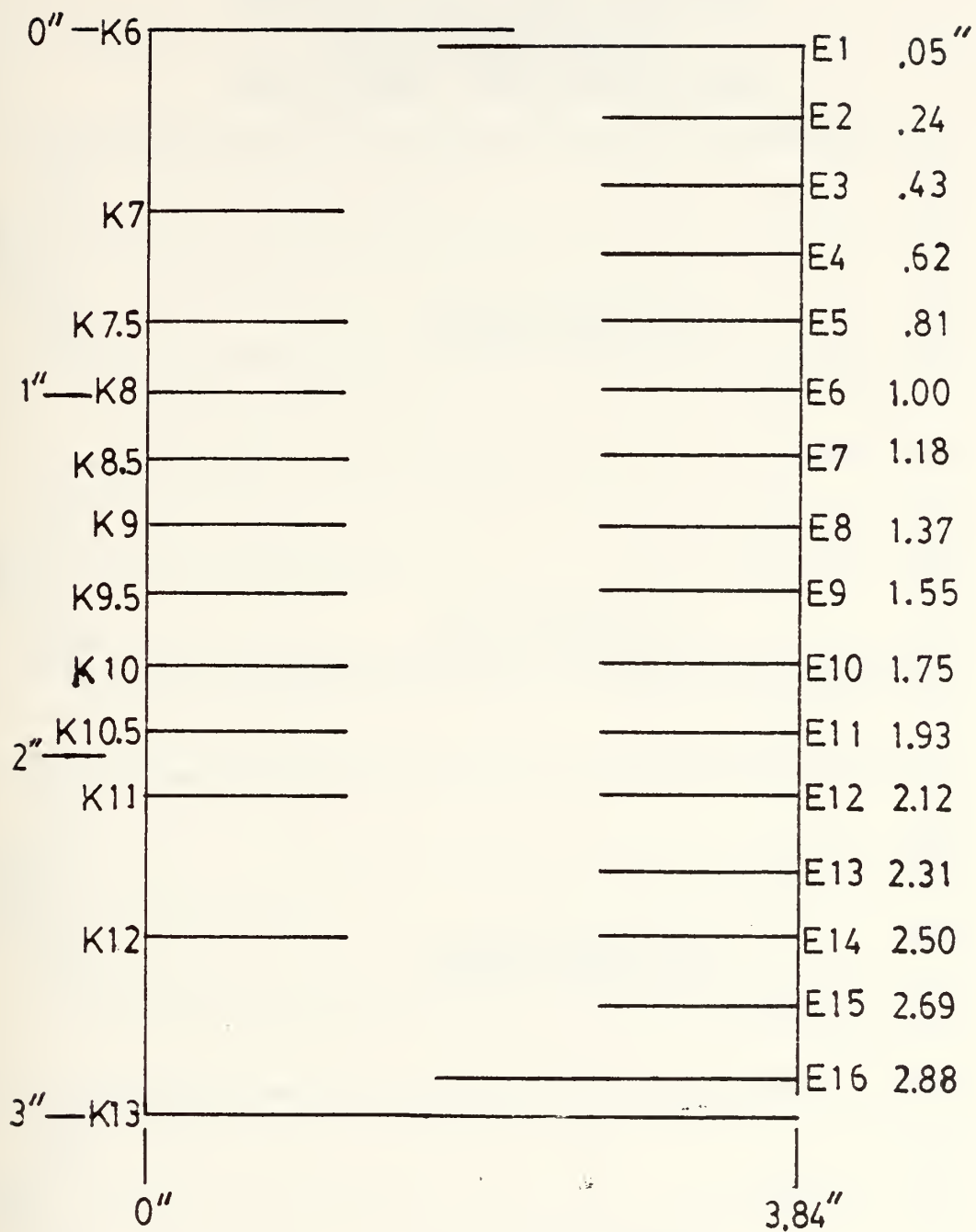


Figure 7 Spacing of Kulite Array and Evened Array

RAW KULITE DATA
RUN 145 PASS 5
70% RPM; OPEN THROTTLE

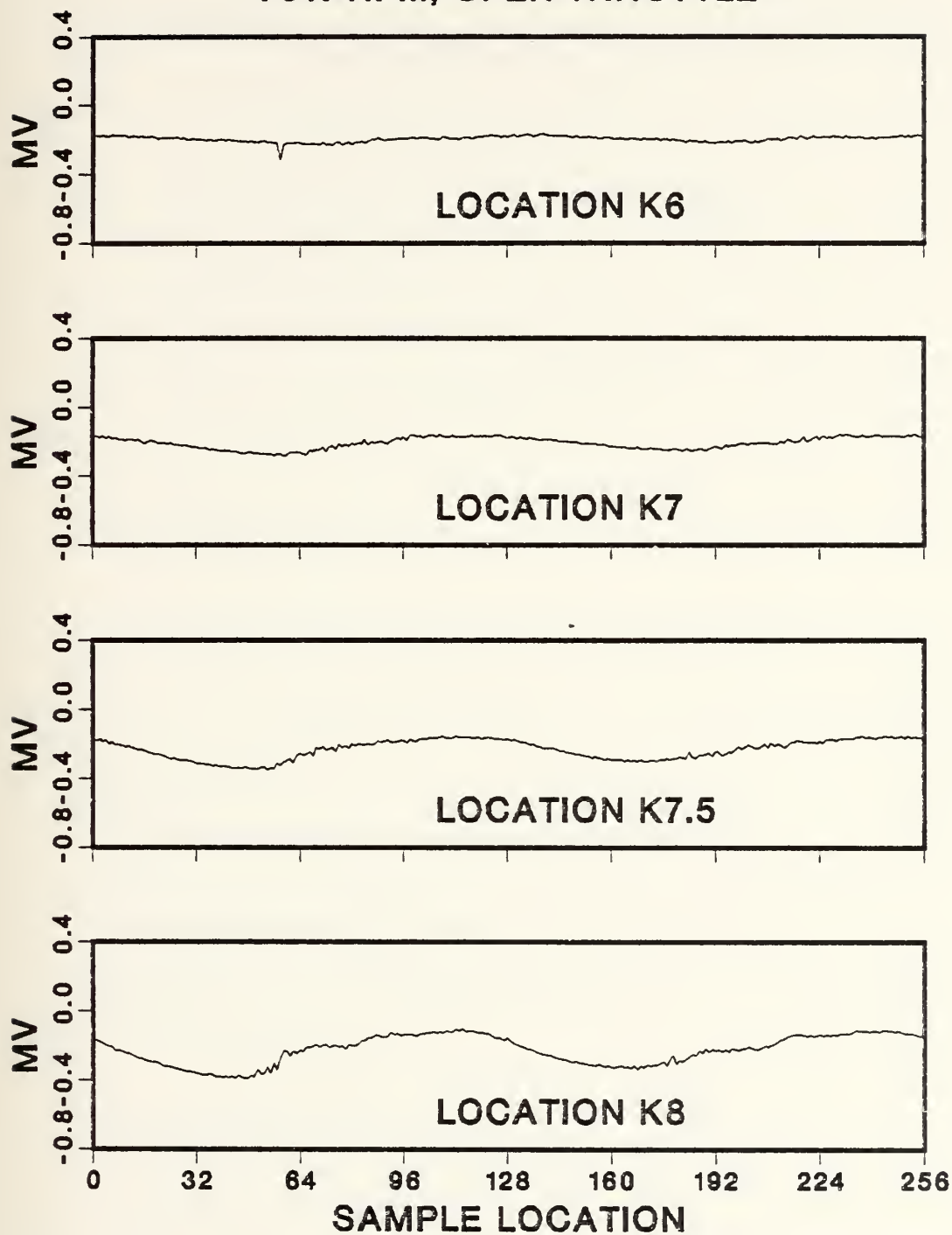


Figure 8 Raw Kulite Data (Continued)

RAW KULITE DATA
RUN 145 PASS 5
70% RPM; OPEN THROTTLE

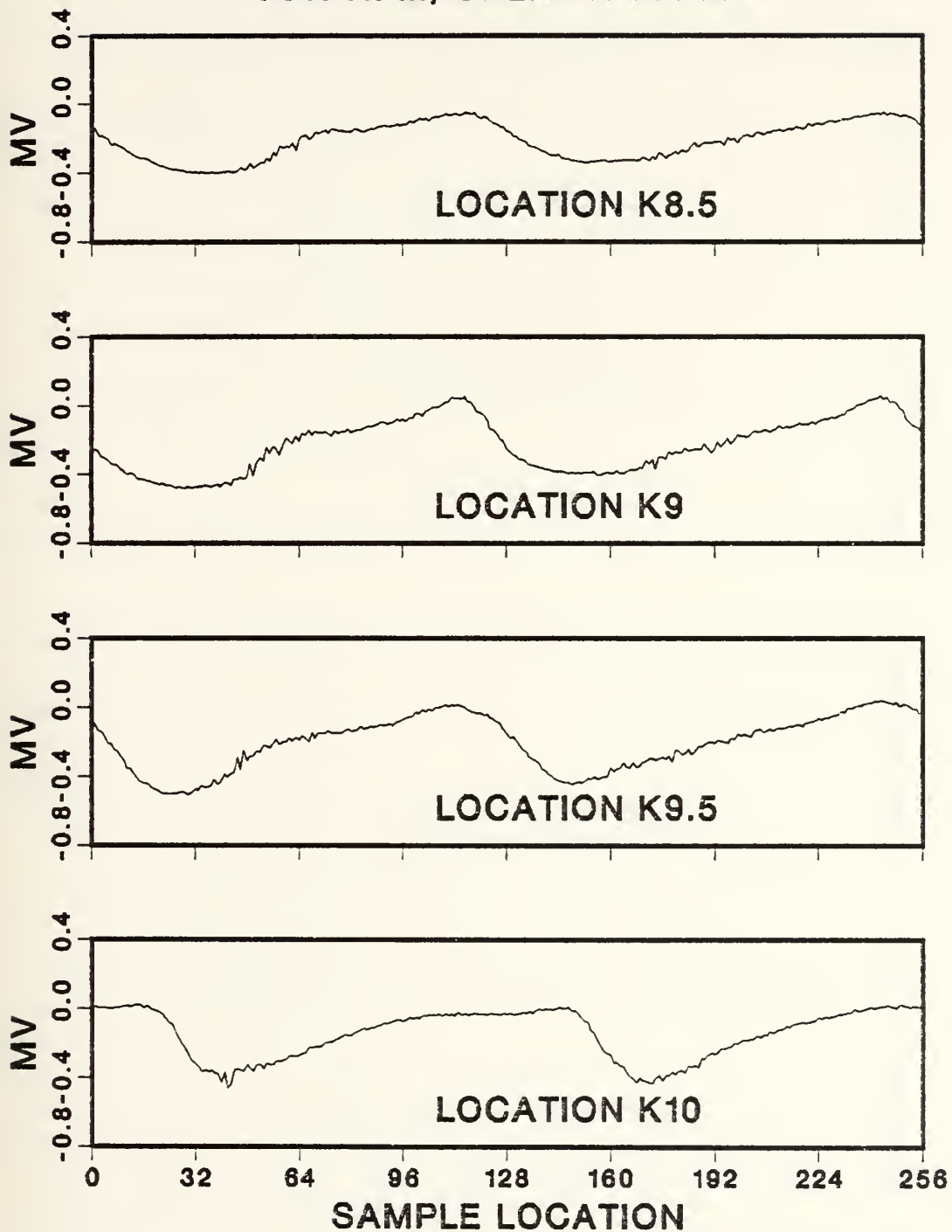


Figure 8 (Continued)

RAW KULITE DATA
RUN 145 PASS 5
70% RPM; OPEN THROTTLE

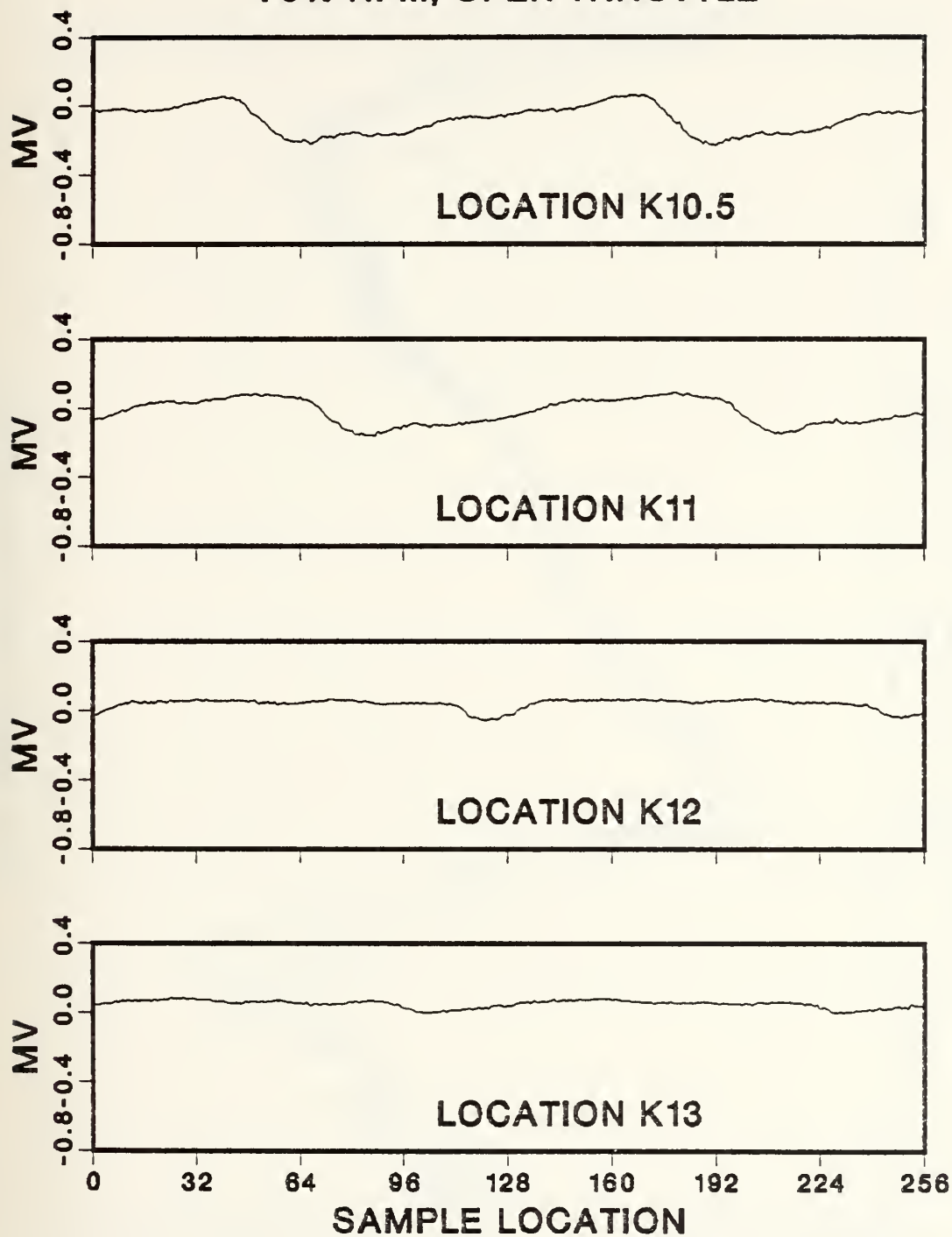


Figure 8 (Continued)

RAW KULITE DATA
67% RPM; OPEN THROTTLE

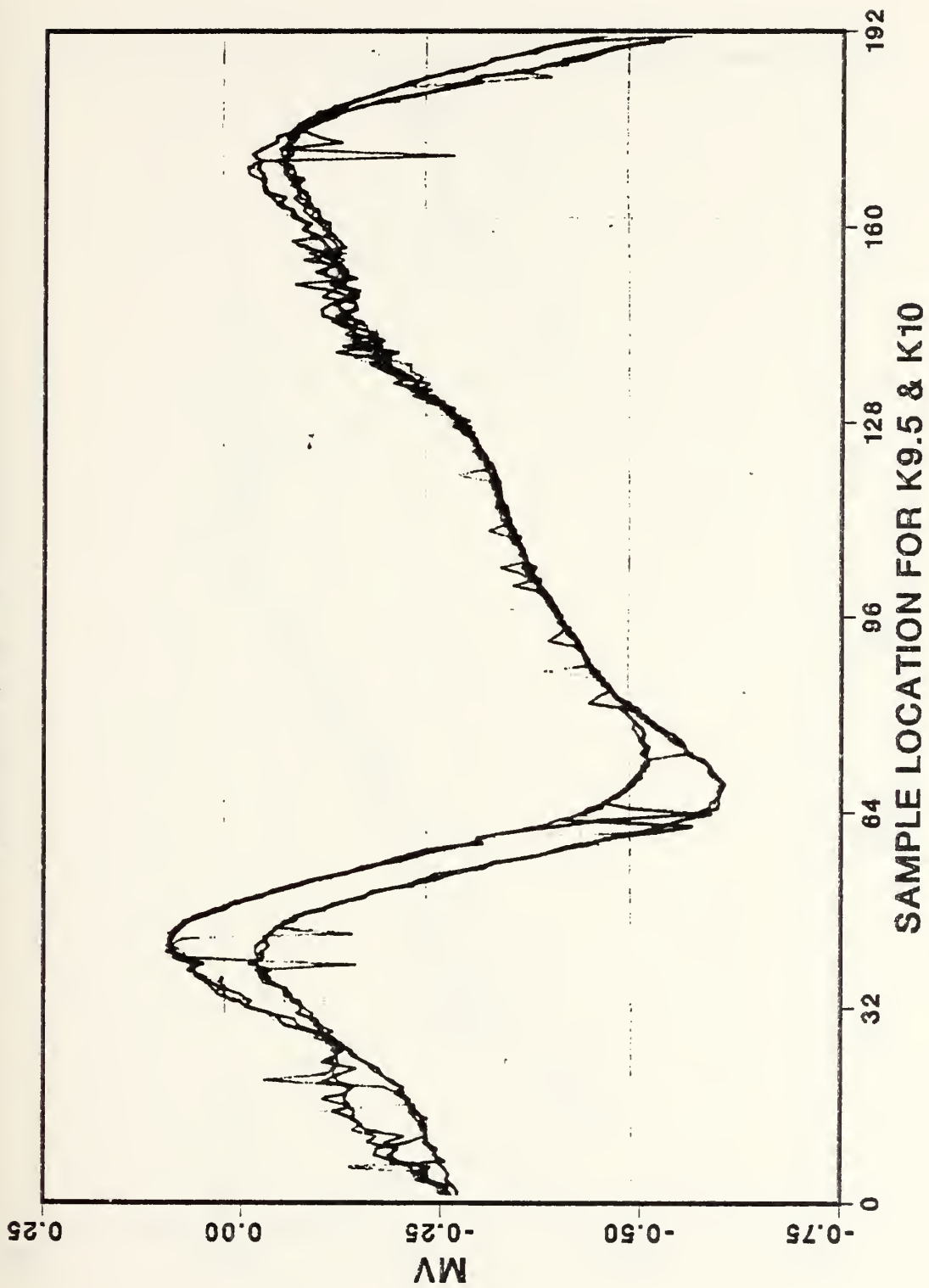


Figure 9 Repeated Data Acquisition

**RAW KULITE DATA
63% RPM; NEAR SURGE THROTTLE**

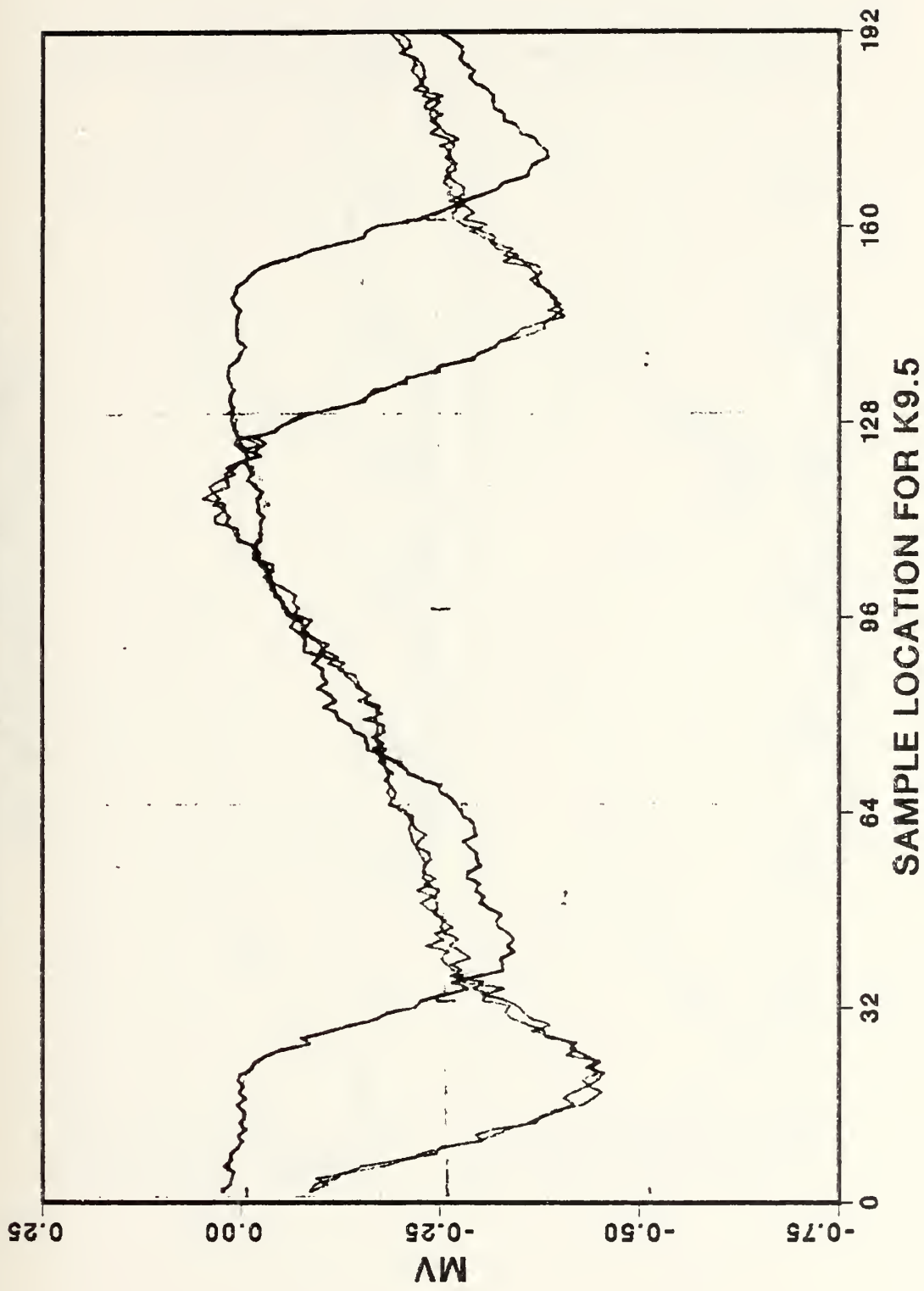


Figure 10 Bi-stable Flow State

70% RPM; DESIGN THROTTLE

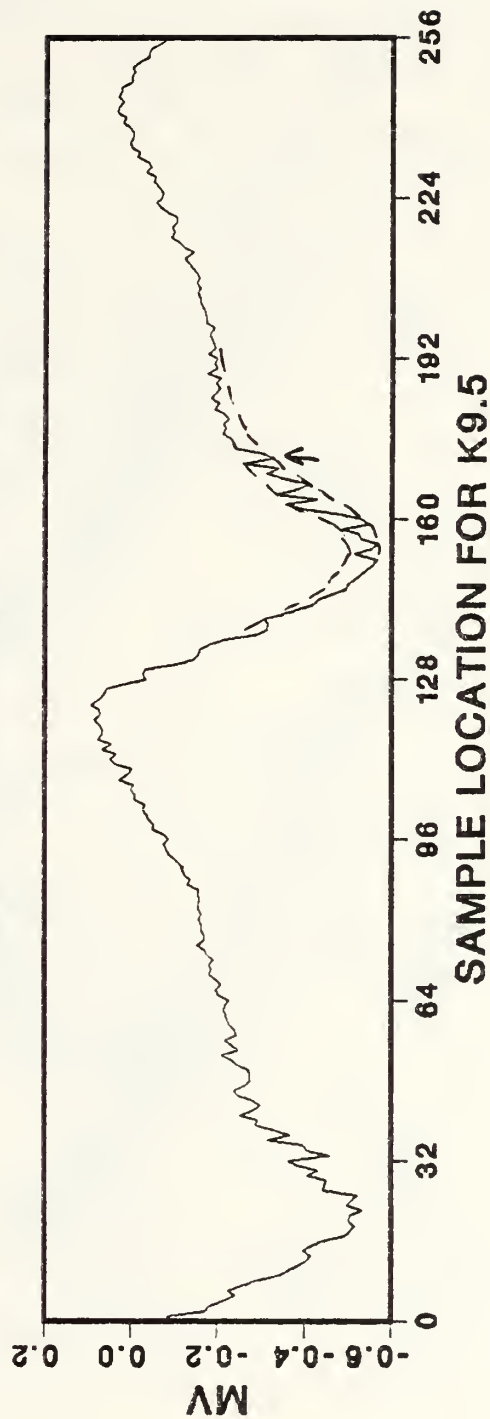
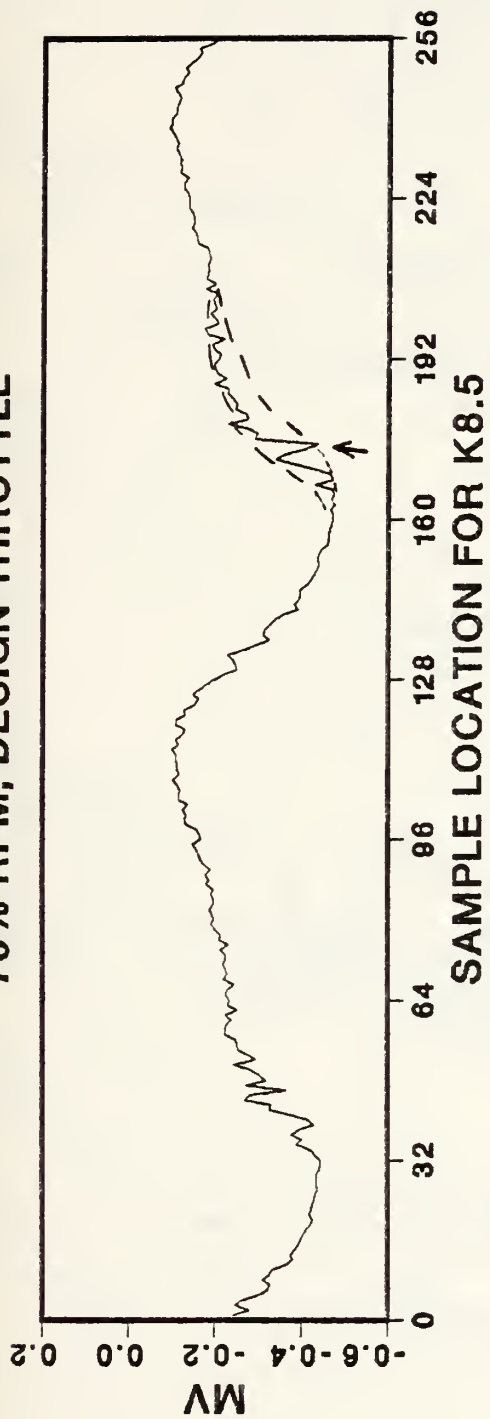


Figure 11 Bi-stable Jumps

70% RPM; OPEN THROTTLE
CONTOUR SPACING = 0.08

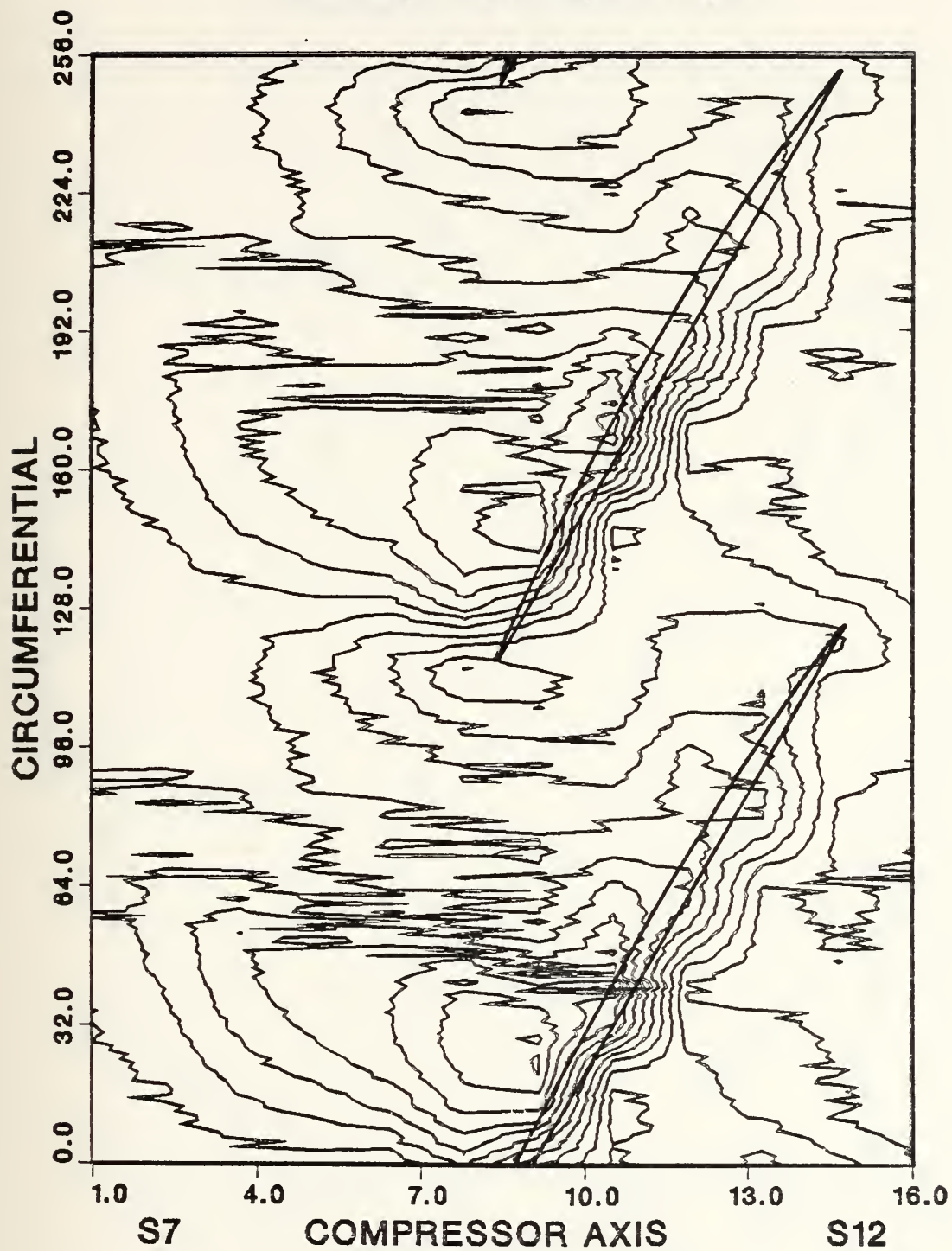


Figure 12 Contour Map of Raw Data

COEFFICIENTS-NO SMOOTHING

CONTOUR SPACING = 0.08

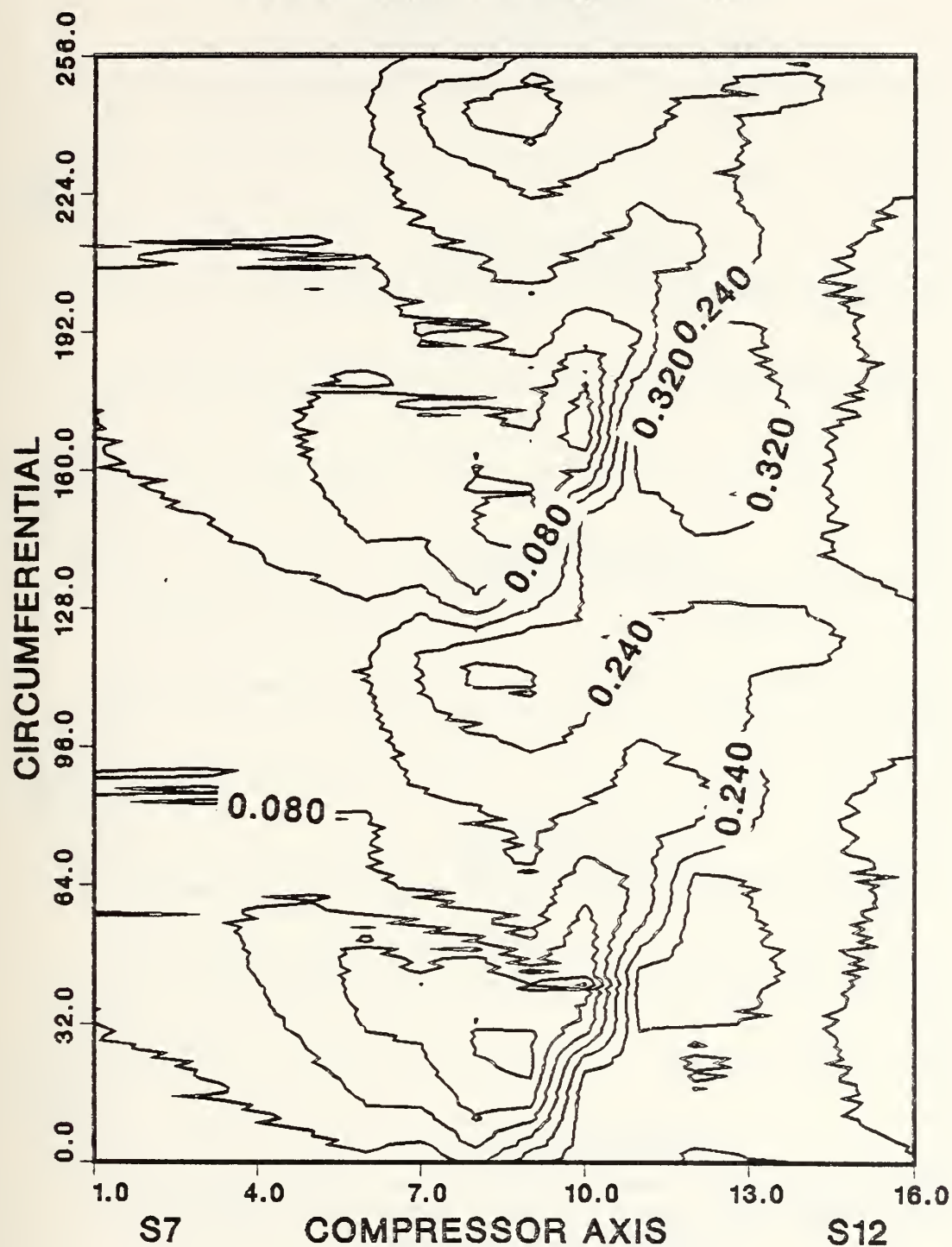


Figure 13 Contour Map of Coefficients (Not Smoothed)

REDUCED KULITE DATA

RUN 145 PASS 5

70% RPM; OPEN THROTTLE

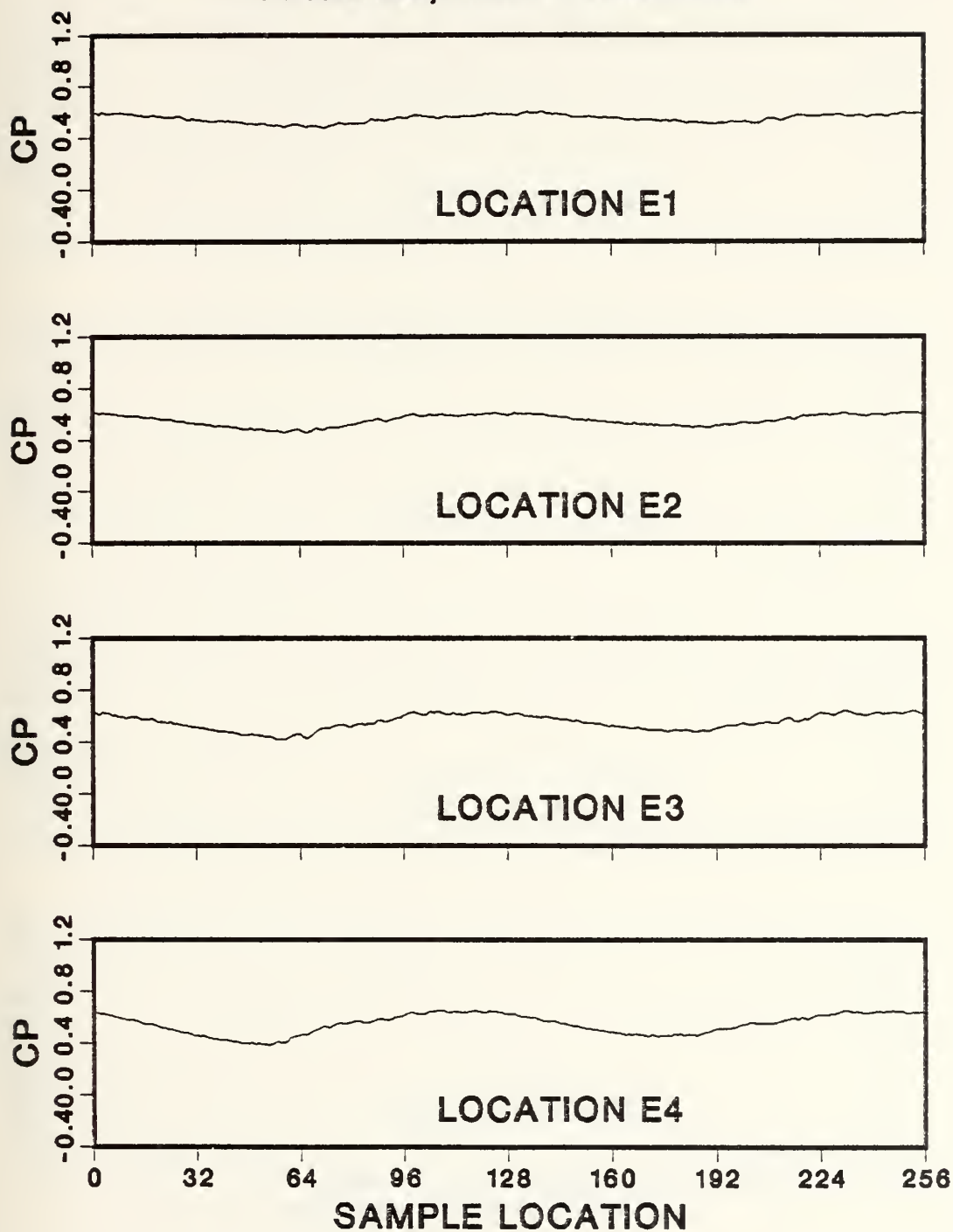


Figure 14 Smoothed Kulite Data (Continued)

REDUCED KULITE DATA

RUN 145 PASS 5

70% RPM; OPEN THROTTLE

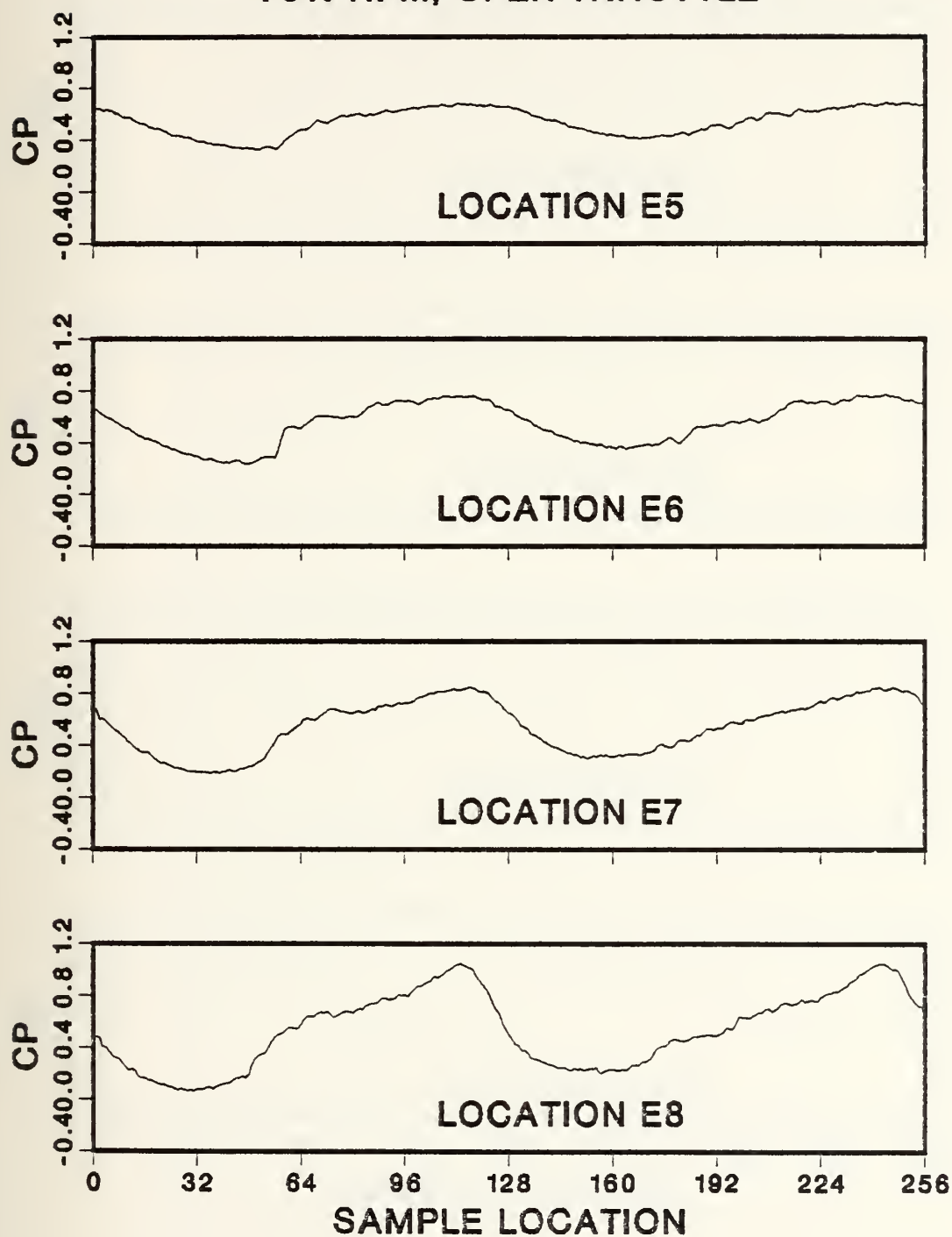


Figure 14 (Continued)

REDUCED KULITE DATA

RUN 145 PASS 5

70% RPM; OPEN THROTTLE

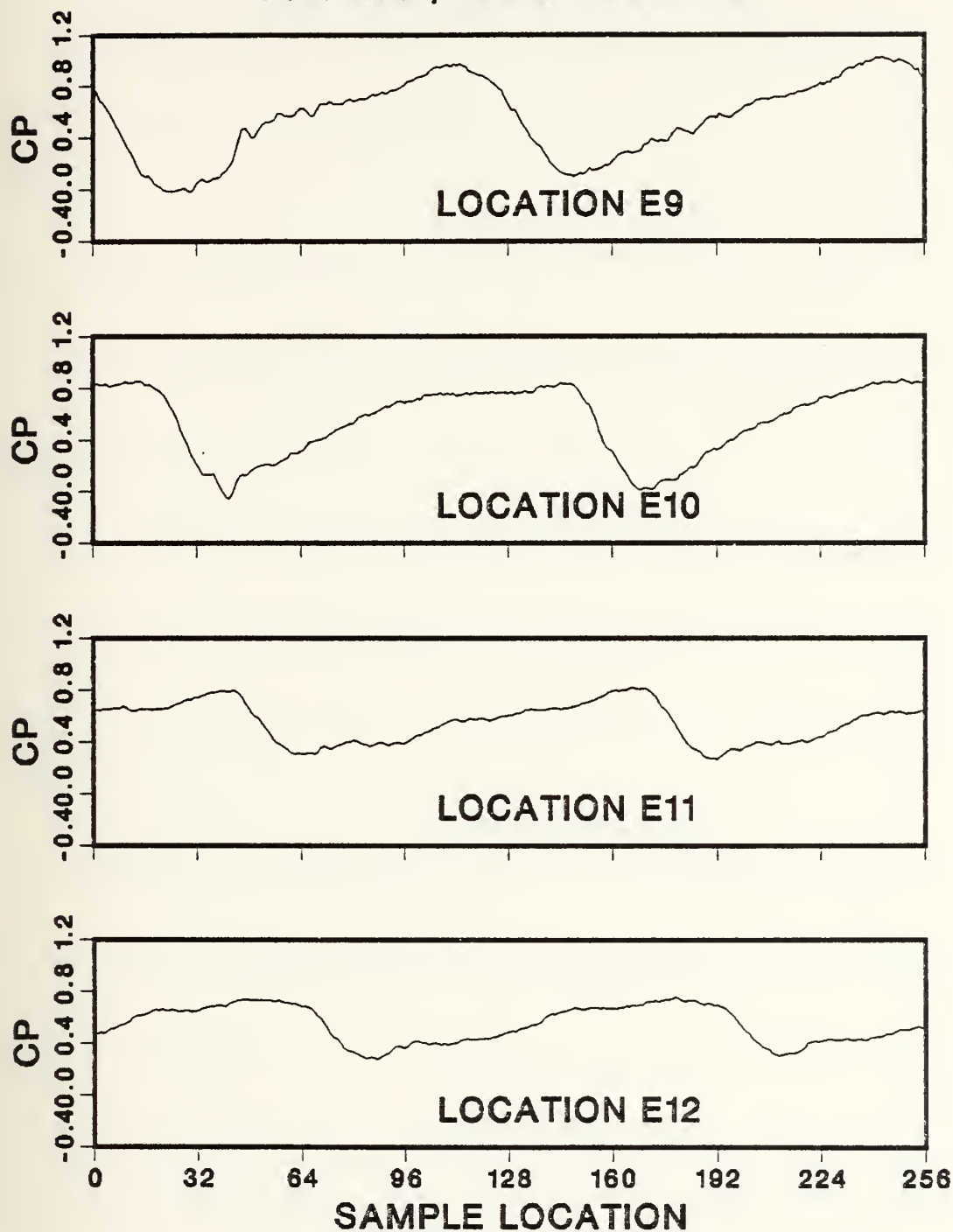


Figure 14 (Continued)

REDUCED KULITE DATA

RUN 145 PASS 5

70% RPM; OPEN THROTTLE

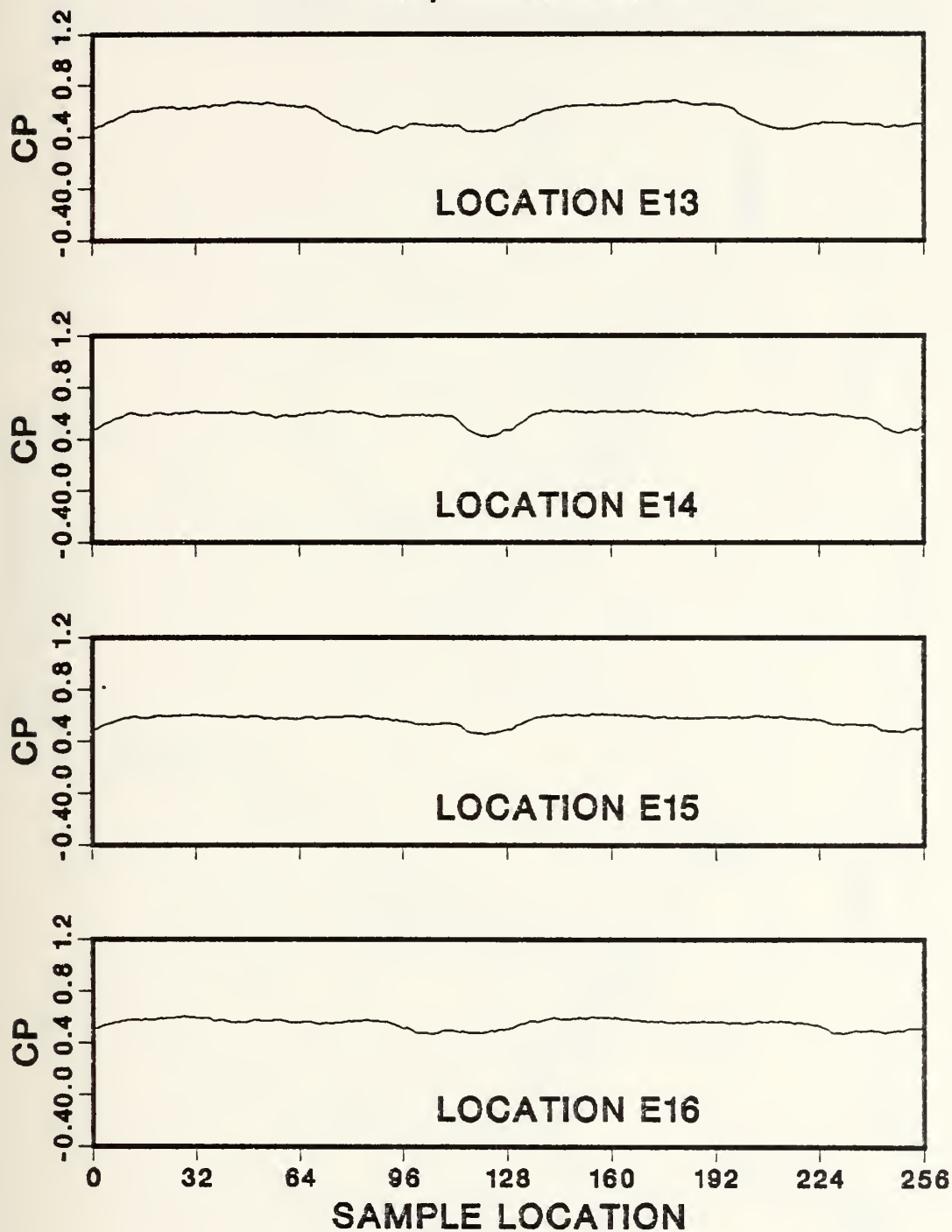


Figure 14 (Continued)

COEFFICIENTS-SMOOTHED CIRCUMFERENTIALLY
CONTOUR SPACING = 0.08

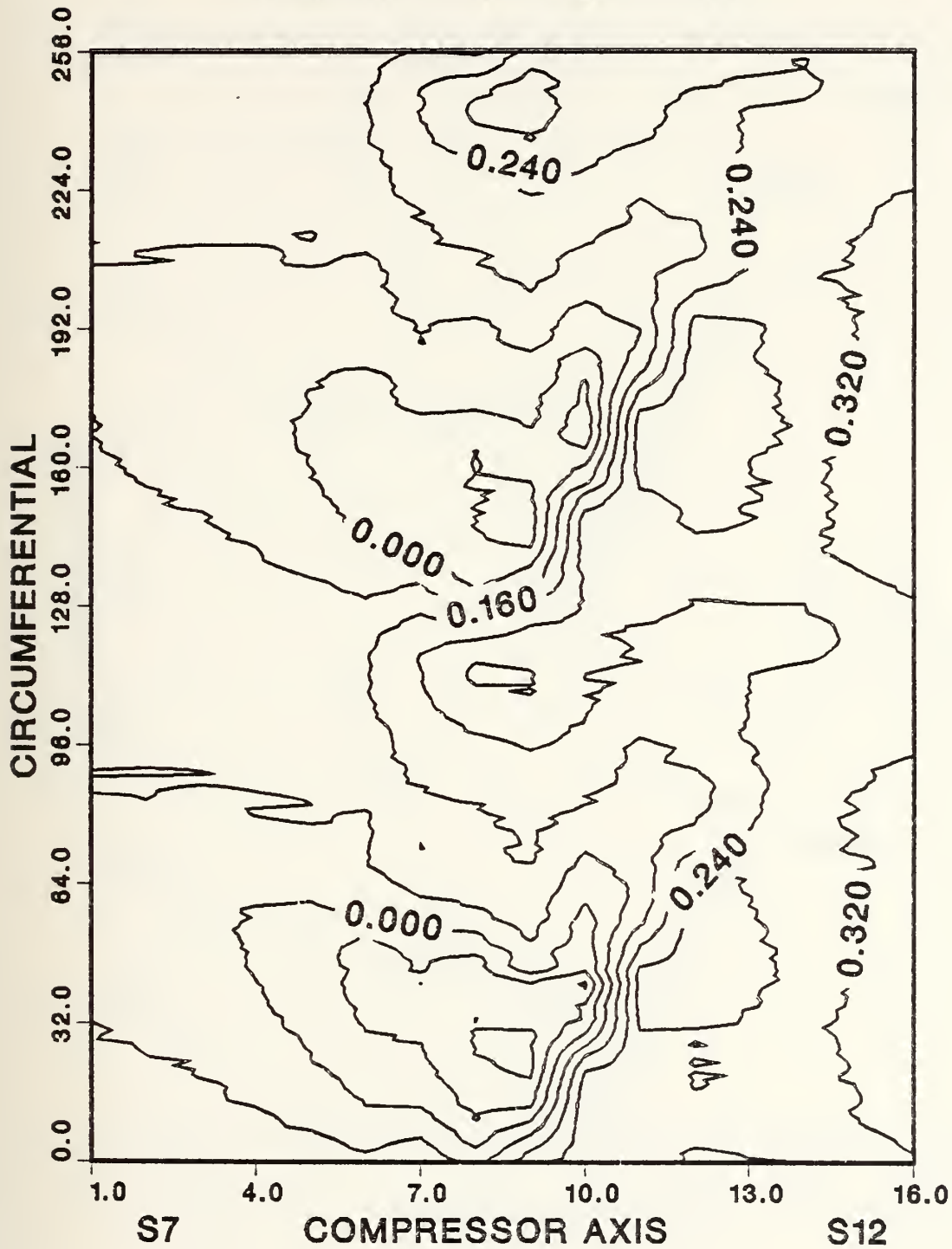


Figure 15 Contour Map of 70% Speed, Open Throttle

70% RPM; DESIGN THROTTLE
CONTOUR SPACING = 0.08

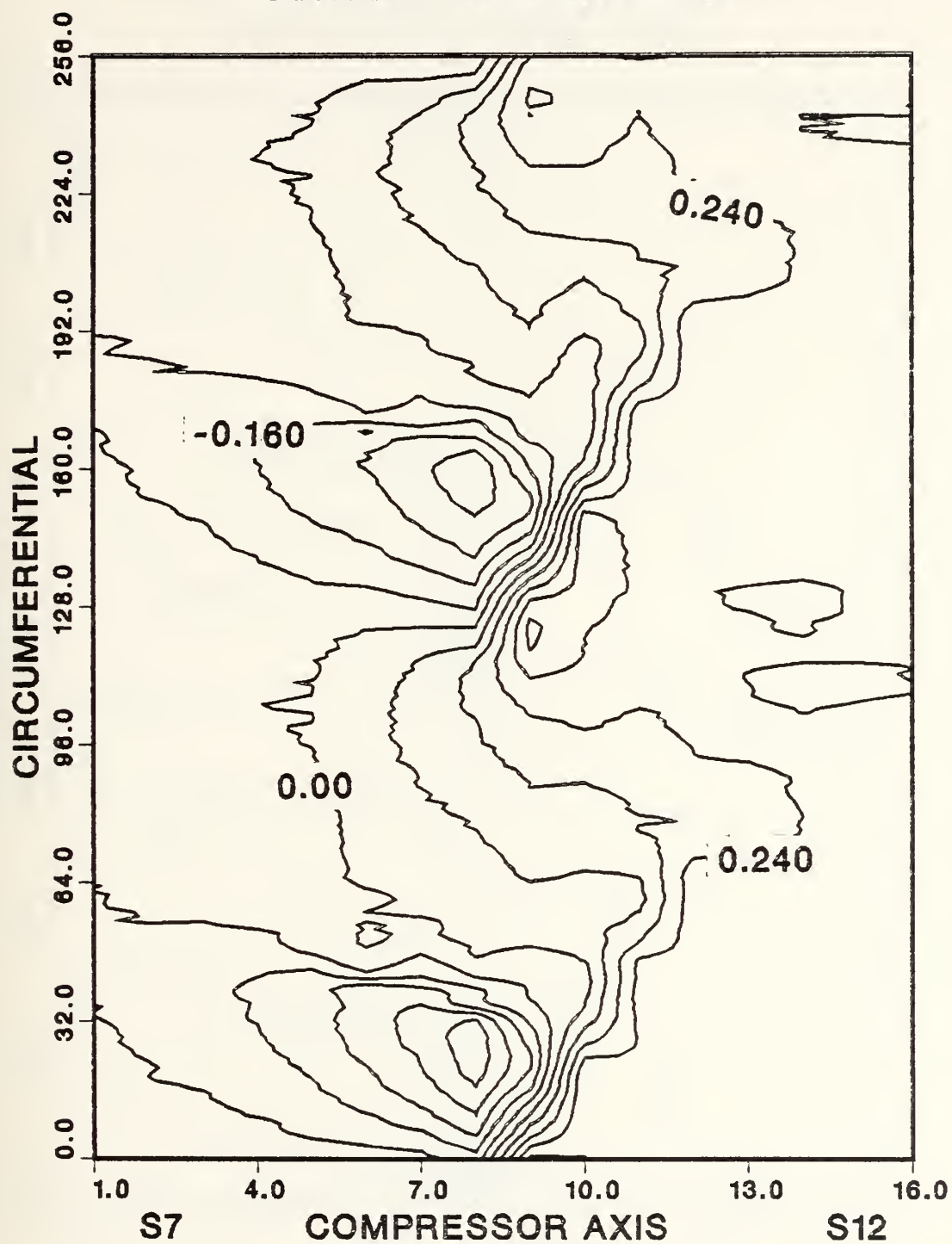


Figure 16 Contour Map of 70% Speed, Design Throttle

70% RPM; NEAR SURGE THROTTLE

CONTOUR SPACING = 0.08

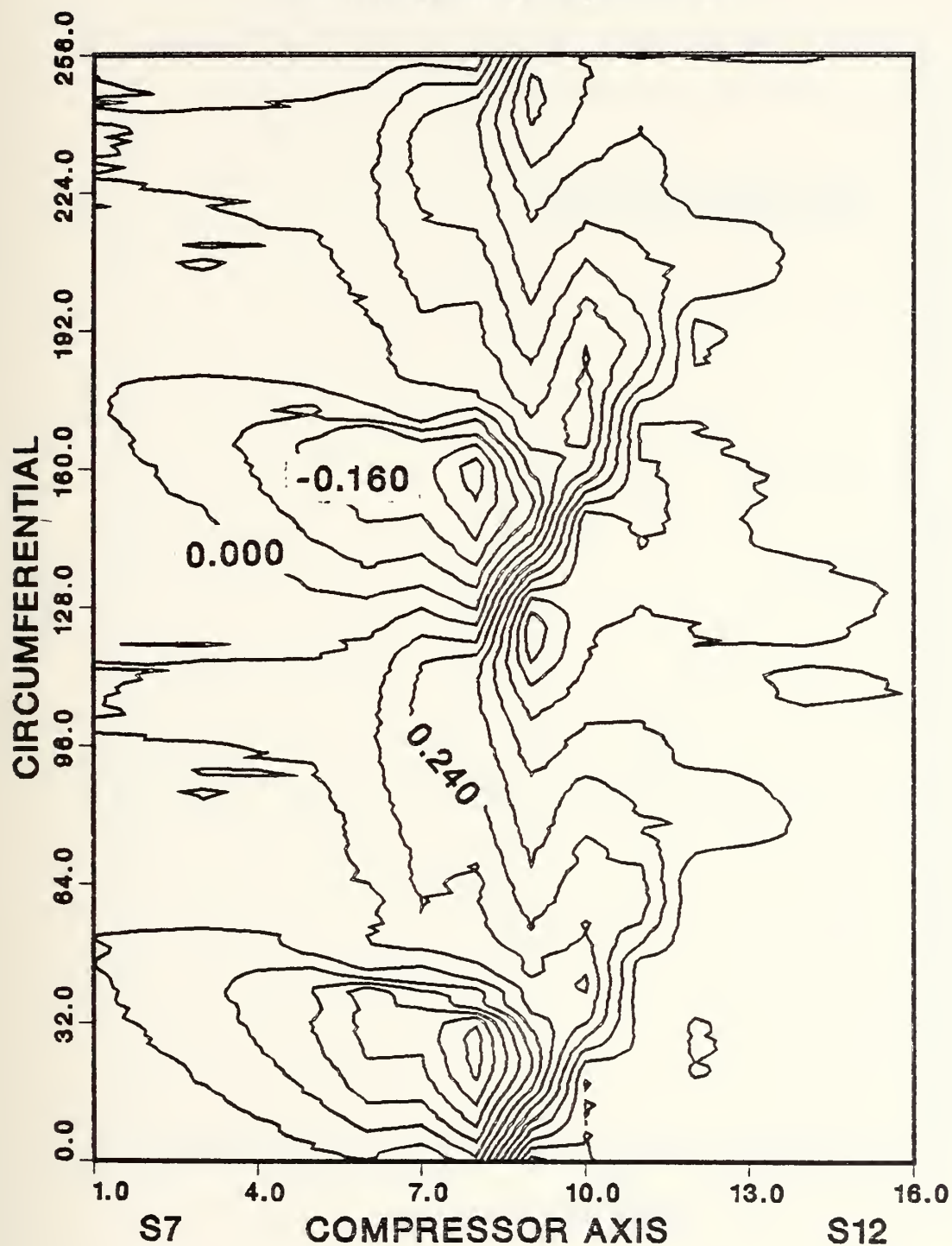


Figure 17 Contour Map of 70% Speed, Near-Surge

PRESSURE DISTRIBUTION

70% RPM; OPEN THROTTLE

RUN 145, PASS 5

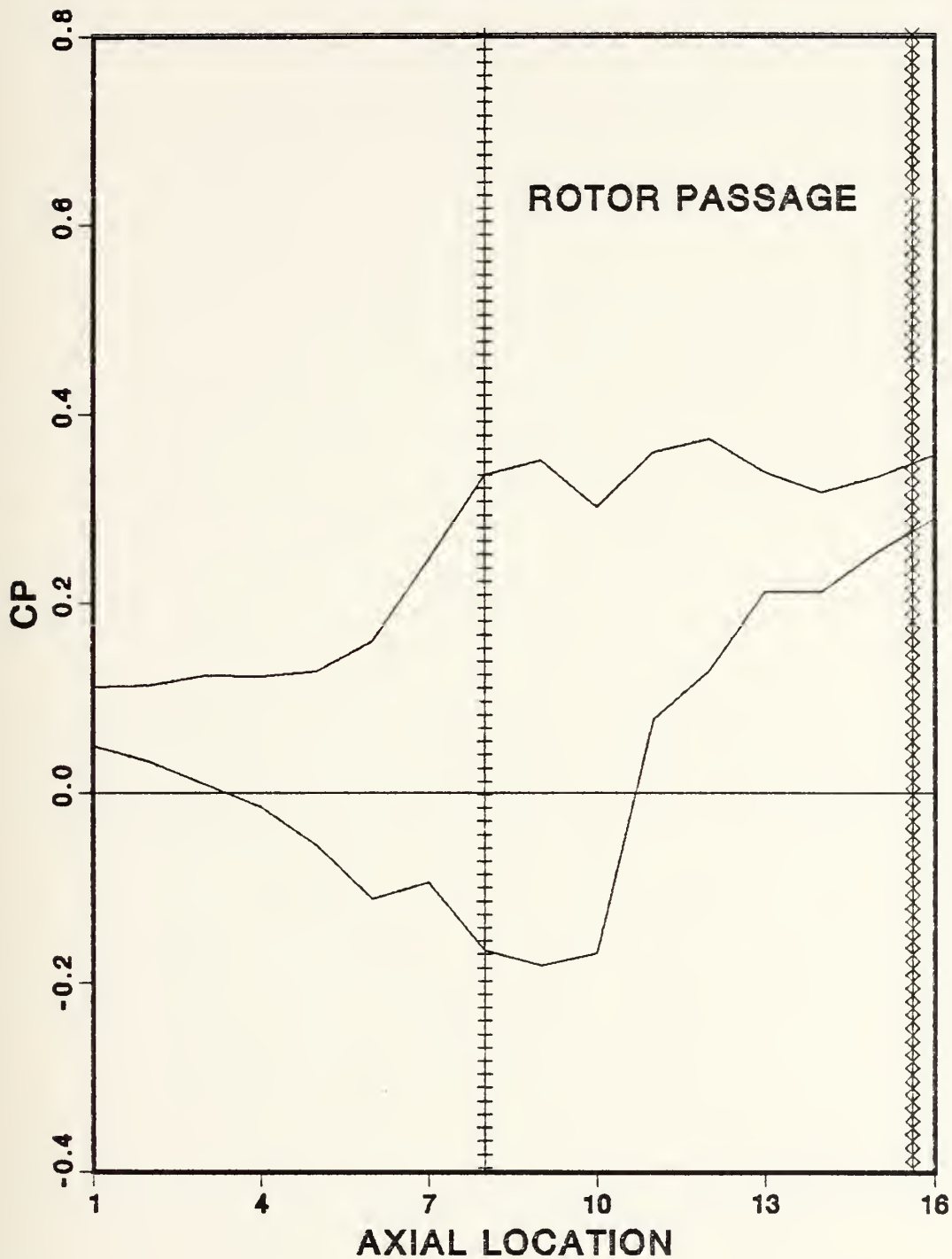


Figure 18 "Blade" Pressure Coefficients, 70%, Open

PRESSURE DISTRIBUTION

70% RPM; DESIGN THROTTLE

RUN 143, PASS 6

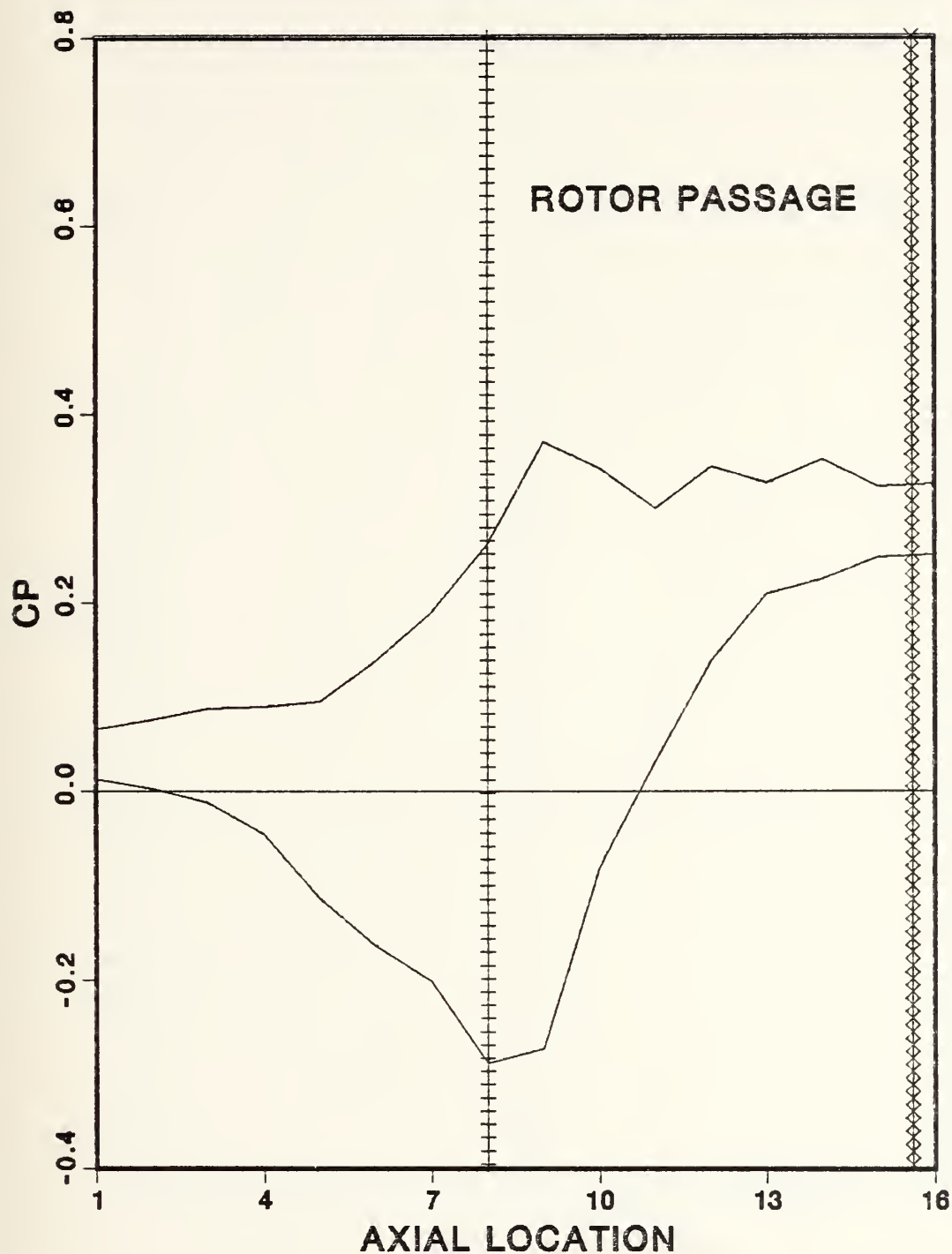


Figure 19 "Blade" Pressure Coefficients, 70%, Design

PRESSURE DISTRIBUTION
70% RPM; NEAR SURGE THROTTLE
RUN 144, PASS 5

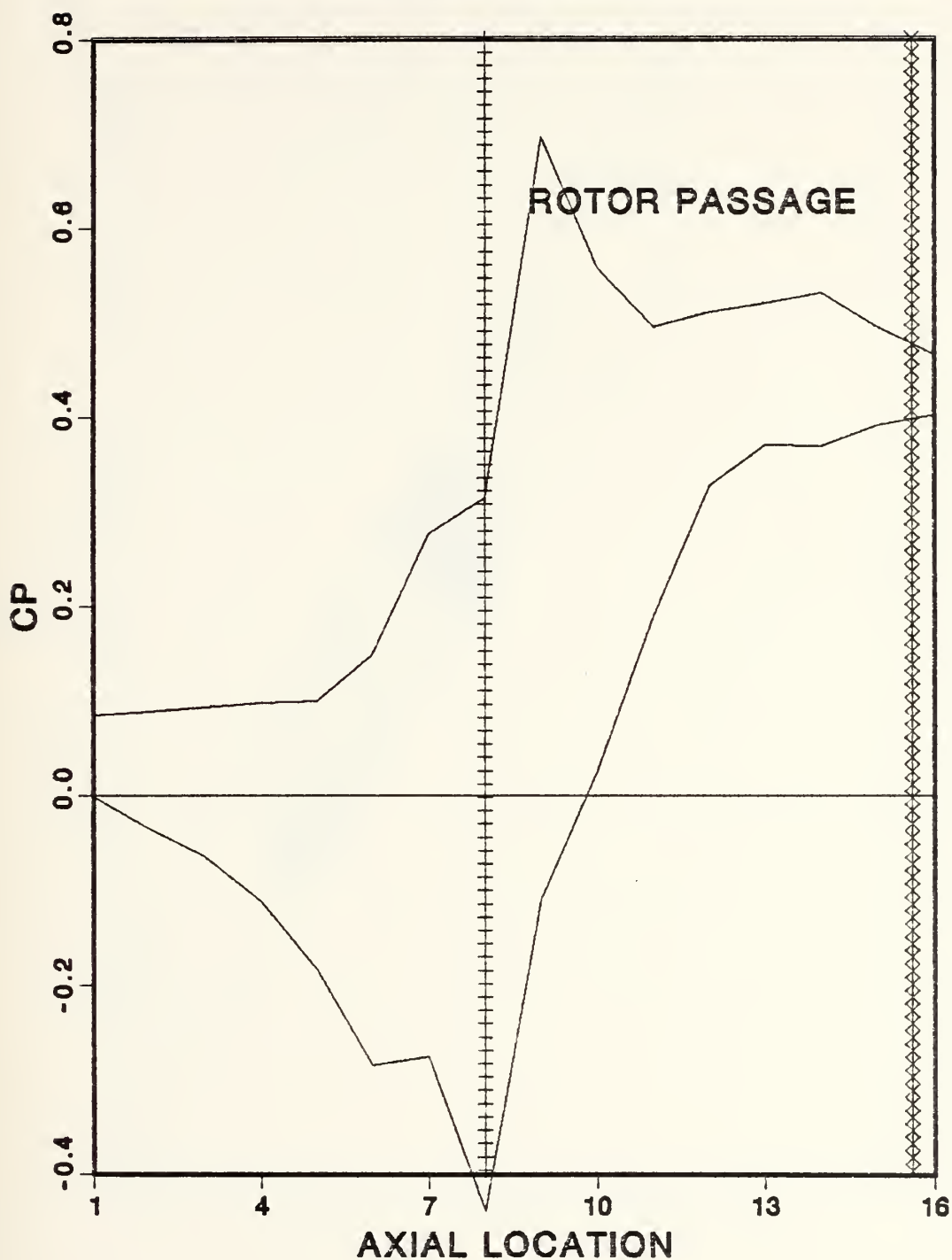


Figure 20 "Blade" Pressure Coefficients, 70%, Surge

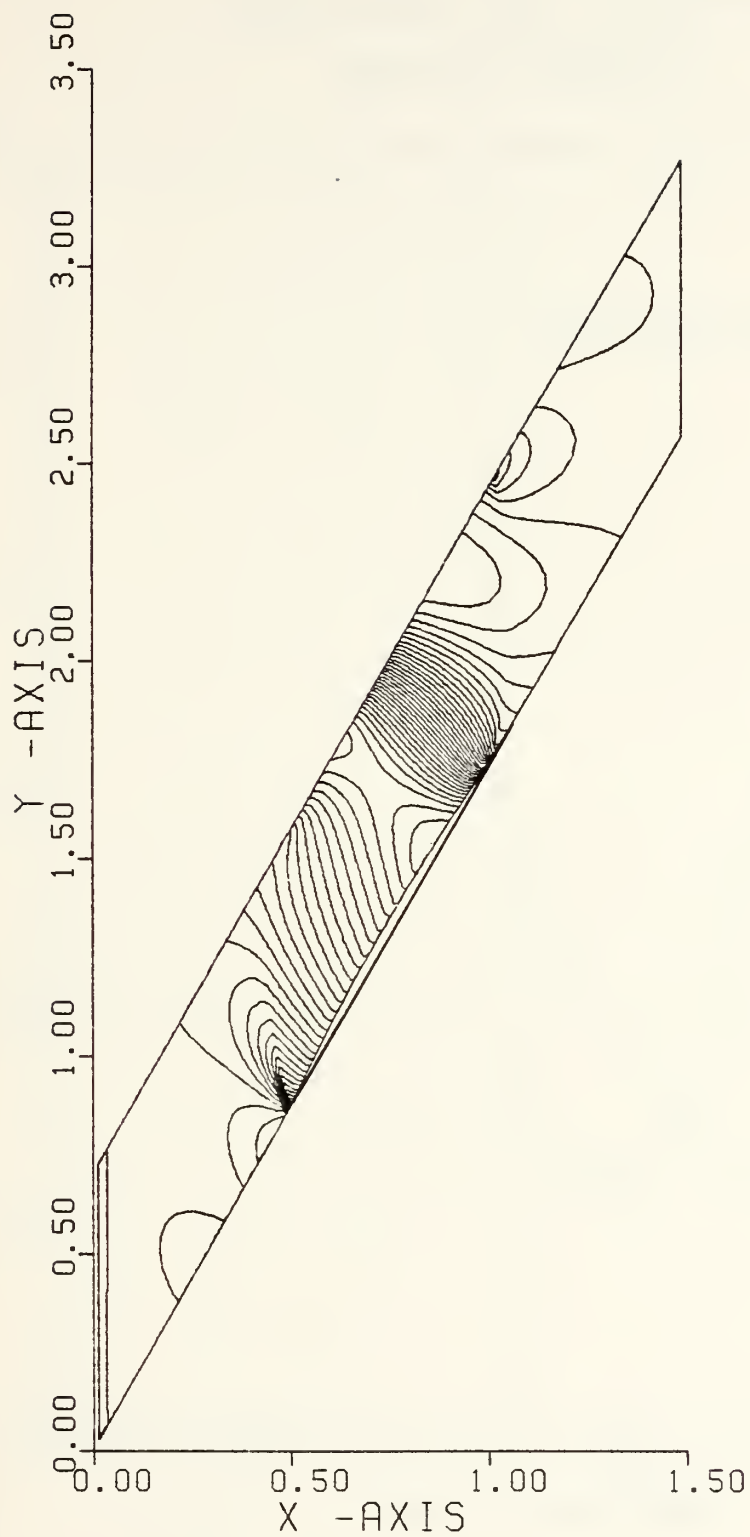


Figure 21 Contour Using Godunov Code

PRESSURE DISTRIBUTION

70% RPM; OPEN THROTTLE

RUN 145, PASS 5

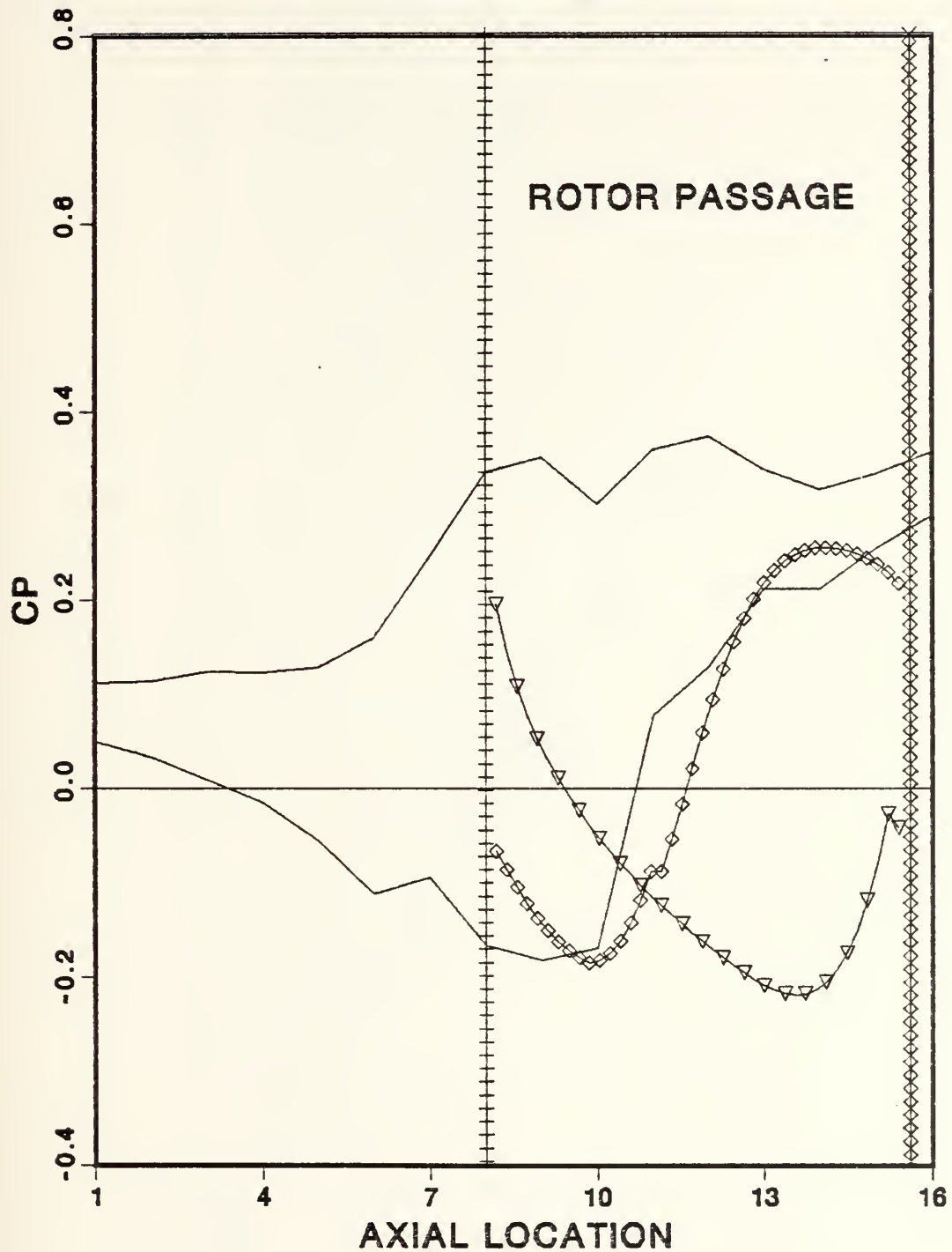


Figure 22 "Blade" Pressure Comparison with Godunov Code

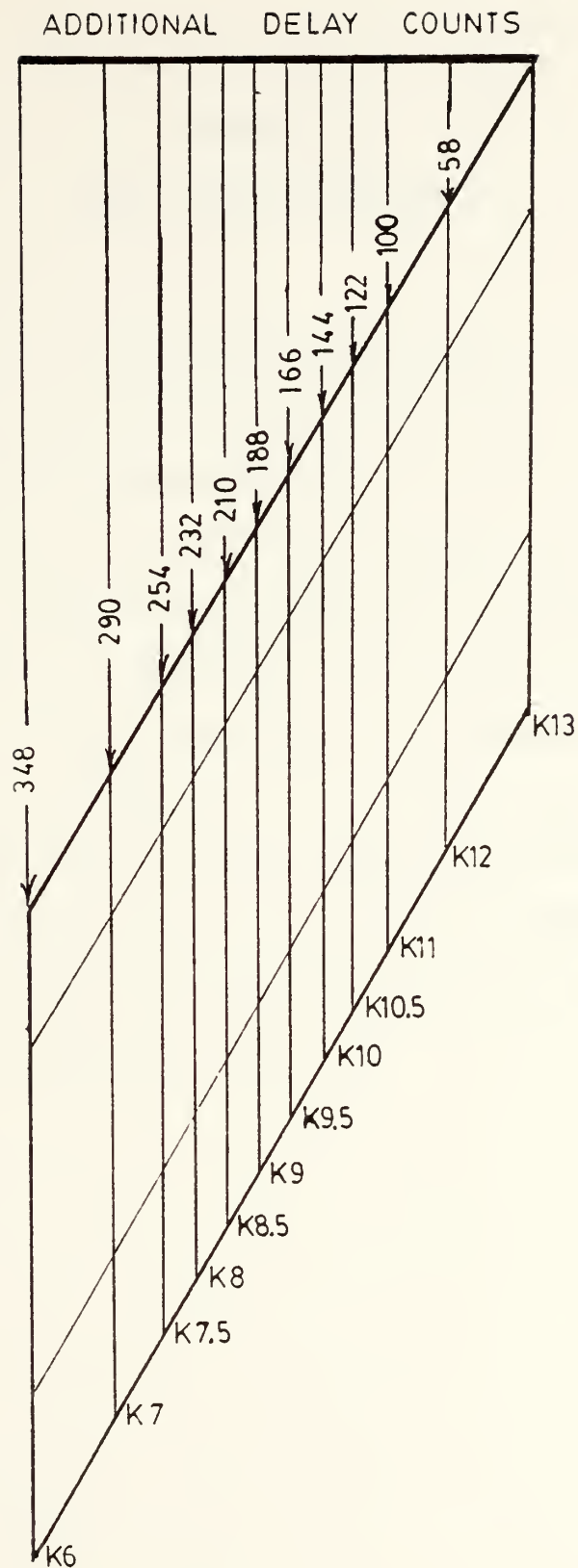


Figure 23 Recommended Data Acquisition Technique

APPENDIX A

ACQUISITION SOFTWARE

A.1 INTRODUCTION

This appendix contains a description of the FORTRAN program WKAQN and its associated subroutines. The intention is to provide a single location for the specific numbers and equations used in the program. This should make it possible to adapt the program easily to changes in hardware configuration or changes in acquisition procedure.

A summary of the acquisition procedure and a detailed user's manual is available in TPL Technical Note 83-01. In the remaining sections of this appendix, each subroutine is described separately with a listing of the FORTRAN code. The functions called were either from the HP relocatable Library, or from Geopfarth [Ref. 6].

TABLE A-1

Subroutines and Functions for Program WKAQN

<u>Name</u>	<u>Purpose</u>
WKOLC	Perform on-line calibration, record steady state and flow data.
CURFT	Calculate linear curve-fit to calibration data.
WKPAC	Interface with Kulite transducers to read unsteady pressure data.
WKRMS	Determines the maximum, minimum, and root-mean-square of the sample set.
XTREM	Calculates the maximum and minimum for a blade passage.

Functions from Geopfarth [Ref. 6]

ACQN	Positions the scanivalve and reads the DVM.
CNTL	Closes the scanner channel.
ICON	Converts 2-digit integer to an ASCII string.
IPORT	Interrogates scanivalve.
SCANR	Closes scanner channel and reads scanivalve or counter.
WAIT	Causes a defined time delay.
Son Program	
WKPLT	Used to plot waveform during acquisition of unsteady data.

A.2 FORTRAN PROGRAM--WKAQN

A.2.1 Description of Program WKAQN

This program is the main FORTRAN program for the acquisition of unsteady pressure in the transonic compressor. The program labels and creates data file space on the disk, performs an on-line calibration of the transducers, records steady state pressures and flow parameters, reads unsteady pressure data and plots the waveform, stores the accepted data, and performs a second on-line calibration.

After the following detailed description, a line by line explanation of the coding is provided. A flow diagram is given in Figure A-1 and a program listing is provided at the end of Section A.2.3.

The program commences with declarations, dimensions, and constant values. Then section "100" is a series of interactive inputs to identify the data files and specify which portions of the program will be used. 'RUN' is the compressor test run number. 'PASS' is the sequential number of data sets taken during the same run.

Section "200" is used to define the data file names from the RUN and PASS entered above and create the space on the mass storage disk. The data files, one for each Kulite data set, are labeled WKxx01 to WKxx12, where xx is the last two numbers of the RUN number. The steady state data, flow parameters, and calibration data are stored in file WKCxxx where xxx is the RUN number. Succeeding passes

would change the label by replacing the K in the name with the PASS number. For example, the data files for the fifth pass on run 145 would be W54501 to W54512 and W5C145.

The files are created on the disk to ensure room is available for the acquired data. Should a cartridge fill-up, options are provided to allow the user to specify another cartridge to store the data. An error code is returned in the 'CREAT' call to identify the location of the error in the program should one occur. The use of the CREAT subroutine and error code is explained in the Hewlett-Packard RTE-IVB Programmer's Reference Manual. [Ref. 16]

The on-line calibration and acquisition of steady state pressure is done in section "300." Although the calibration is optional, it should be done for each complete set of Kulite data acquired. The program calls the subroutine WKOLC if the option is chosen. The array OLCAL is used to store the calibration data, pneumatic pressure data, and flow parameters. The main program calculates RPM from a reading of 1/6 revolutions per second. Therefore, rotor-shaft speed is converted to RPM by a factor of 10.

The mass flow rate is calculated to provide throttle information used to identify the compressor running conditions. The method used is taken from Shreeve. [Ref. 20]

The acquisition of unsteady data is performed in section "400." After printing the output heading, the user enters the number of samples to be taken and the blade pair.

The number of samples is the number of Kulite pressure readings that will be taken at one of the 256 blade-to-blade locations. Since this would create an enormous amount of data, only the average of the sample set, a root-mean-square of the set, maximum, and minimum values are retained. The blade pair identifies for which of the nine blade pairs of the rotor that the pressure data will be recorded. The subroutine WKPAC performs the actual acquisition and the calculation of the retained data. The data is stored in a 4 x 256 array labeled ARRAYA as follows:

Row 1	Average pressure data
Row 2	RMS values
Row 3	Maximum values
Row 4	Minimum values

Subroutine 'XTREM' is called to calculate the maximum and minimum value of the data in each of the two blade passages which is output on the printer. The average is also calculated for each blade passage which is essentially the steady state value of the pressure at the axial location.

The average data from the first row of ARRAYA is then plotted in section "500" to observe the waveform using the 'son' program WKPLT. A complete description of father-son programming is available in the HP RTE-IVB Programmer's Reference Manual. [Ref. 16: Chapter 2] The program is called by the 'EXEC' at line 193 in the program listing. The

statement following is only executed if an error occurs when calling the son program.

Once the plot is finished, the user has the options of retaking the data, accepting the data, or exiting. The alternate of the two graphics output devices, terminal or plotter, can be selected at this point. If the data is repeated, the previous data is erased. If the data is accepted, it is stored in its predesignated file on the disk. Section "600" opens the file, writes the data from ARRAYA into the file, and closes the file. Note that all of the FMP subroutines are used with the error processing feature described for CALL CREAT above. The extreme values and average for each blade passage are output on the printer.

At this point, the acquisition is complete for one Kulite transducer and the program returns to section "400" to repeat the procedure for the next and subsequent Kulites. When the last of the unsteady pressure data is accepted, the program advances to the second on-line calibration.

The second calibration is similar to the first using subroutine WKOLC. After the calibration is complete, the array OLCAL is written into the file WKCxxx using the FMP calls described above.

The acquisition procedure is then complete the user has the option to exit or return to the beginning for another set of data.

A.2.1 Program--WKAQN Details

<u>Line No.</u>	<u>Equation/Constant</u>	<u>Origin</u>
29	GAIN = 40.0	The amplifier gain from the fast response semi-conductor transducer to the A/D converter.
31	IDCBS = 144	See Reference 16, Chapter 3.
31	ITYPE = 1	Data file, see Reference 16.
31	IL = 2048	Length of 4 x 256 data array; 4*256 reals/row * 2 words/real
31	JL = 1024	Length of 2 x 256 on-line cal array, OLCAL.
31	KL = 512	Length of 1 x 256 data array, used with plot routine WKPLT.
32	MASK = 177700B	Saves only 13 digits of number read by A to D converter.
32	INUM = 1	Resets plot counter to 1.
33	ISIZE = (16,128)	Size of buffer needed for file. DATMAT, when storing on disk. All type 1 files have rows 128 words long. [Ref. 16]
33	JSIZE = (8,128)	Same as above, for OLCAL array.
35	COC = 1.03	Contraction ratio of channel.
35	R = 287.06	Gas constant 287.06 N-m/Kg-K.
35	G9 = 1.402	Ratio of specific heats.
49	PATM = PA * 13.57	13.57 in. H ₂ O per in. HG.
97	JJ = 1	Used with the line directly above. With CALL CREAT, (or any other file

<u>Line No.</u>	<u>Equation/Constant</u>	<u>Origin</u>
		management calls), a return variable is used to identify problems. The next several lines of code use IERR to clear some particular probs. Error codes are listed in the HP RTE-IVB Reference Manual, [Ref. 16] Chapter 3. Note: Regardless of the error number, a statement (line 310) is returned to the terminal. JJ=1 identifies the error with this CALL CREAT. Note: line 121 uses a different value of JJ.
138	RPM = OPCAL(1,103) * 10.0	The machine speed is measured in revs per 6 seconds.
139	TT = OLCAL(1,106) * 1000. * 34.7279 + 32.6149	Total temperature from Type J Iron-Constantan thermocouple is recorded in microvolts, converted to millivolts and multiplied by slope from the chart provided for the probe. Note: 32 degrees subtracted off in preparation for conversion to degrees Kelvin.
140	TT = TT * 5/9 + 273.15	Conversion from Fahrenheit to degrees Kelvin (32 subtracted above).
141	P1NC=((OLCAL(1,82)-OLCAL(1,79))*100000.+PATM)*249.0881	Pneumatic pressure measured at the nozzle is stored in OLCAL(1,82). As with all pneumatic measurements, a zero or Tare, recorded in OLCAL(1,79)

<u>Line No.</u>	<u>Equation/Constant</u>	<u>Origin</u>
		for scanivalve #1, is subtracted. The resulting voltage is multiplied by 100000.0 to get pressure in units of inches of water. This is accurate gage pressure which is added to the atmospheric pressure for a total pressure. The factor at the end converts inch of water to Newtons per meter squared.
142	DPNC = (OLCAL(1,82)-OLCAL(1.83)) * 10000. * 249.0881	The difference in pressure P1 and P2 is a difference in gage pressure and since the tare is the same for both readings, they are omitted. Units-N/m-m.
143	RO = 6.0 * .0254	Radius of flow meter 6 inches times .0254 meters/inch.
144	AOC = 3.141593 * (RO * RO)	Area of flow meter.
145	MFL = SQRT(2 * (P1NC * DPNC) / (R * TT)) * 2.204634	Mass flow rate described in reference 8. Multiplied by factor to convert Kg/sec to lbm/sec.
146	MFLC = MFL * (1 - (3 * DPNC) / (4 * G9 * P1NC)) * (COC * AOC)	Referred flow rate. [Ref. 20]
189	ICODE = 9 + 100000B	Sets input for CALL EXEC 9. Schedules "son" program and waits. The binary bit sets no abort for an error. Allows the next statement after the call to be executed if an error occurs in program WKPLT. If no error occurs, the program skips to the second following statement.

<u>Line No.</u>	<u>Equation/Constant</u>	<u>Origin</u>
190	IP(2) + PLOTLU	Input parameter for WKPLT plot routine.
191	IP(3) = INUM	Input parameter for WKPLT.
192	IP(4) = ADCHNL-1	Kulite number (1-12).
196	CALL RMPAR(IP)	Recovers IP parameters from the son program. [See Ref. 16]
197	IP(1) = 100000B	Return value of IP(1) if an error occurs.
199	ICODE = 14+100000B	Sets input parameter for CALL EXEC 14. Retrieves data array from WKAQN for plot program.
261	ISP = ATOD(L) + 88	Converts Kulite number (1-12) to the location in the OLCAL array where the corresponding pneumatic pressure resides. (See Fig. A.3, p. 93)
262	IF (L .GT.10) ISP = ISP + 1	Allows for pressure tap 11.5 without corresponding Kulite.
263	SP = OLCAL(1,ISP)*100000.	Average pressure at Kulite location in inches of water.
296	PASS=PASS + IGO	Increments PASS which redefines data files.

WKAQN

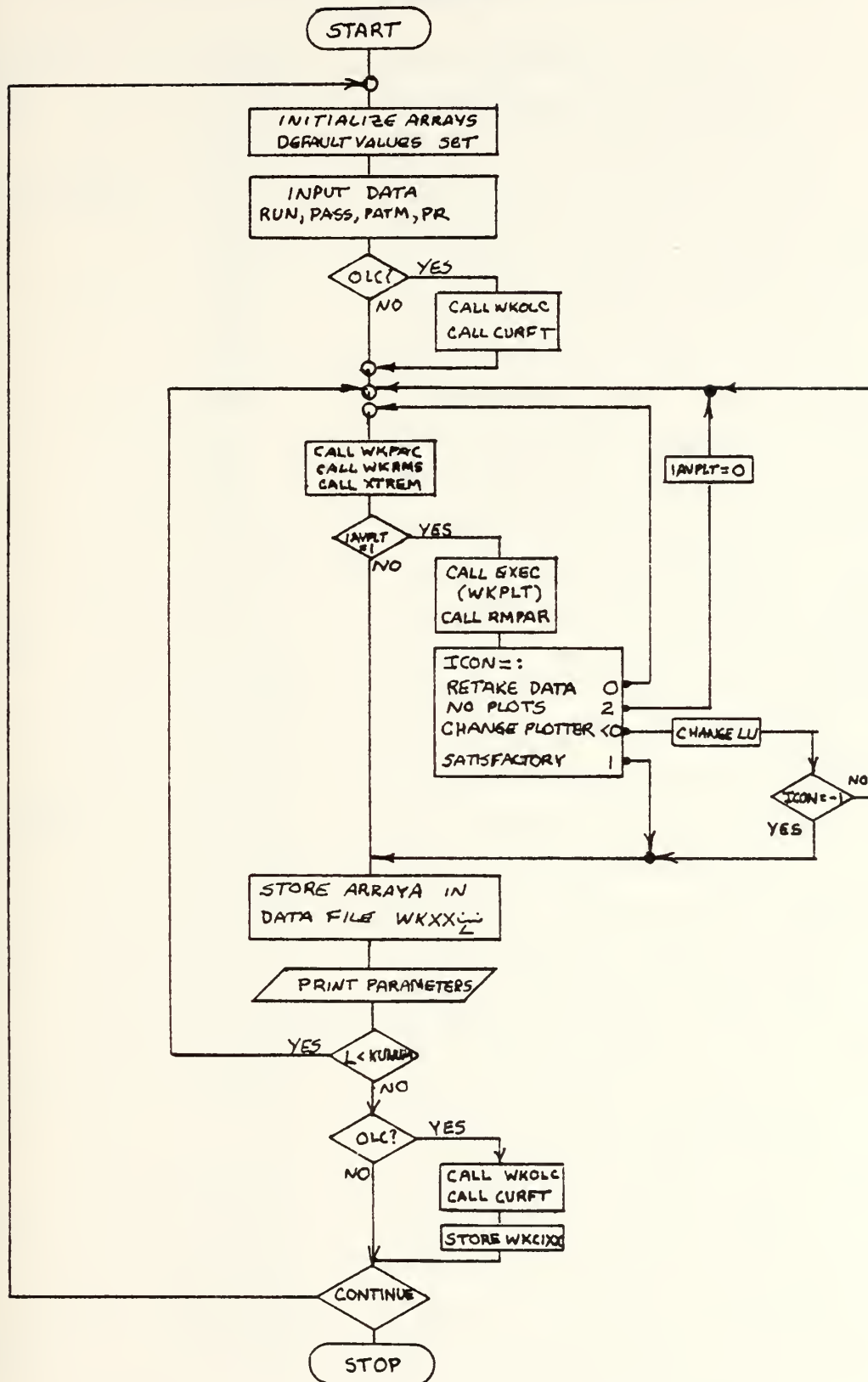


Figure A.1 Flow Diagram of Program WKAQN

A.2.3 Nomenclature & Listing for Program WKAQN

ATOD(12)	integer	A/D convertor channels
ADCHNL	integer	Incremented a/d channel
AOC	real	Area of flow meter throat
ARRAYA(4,256)	real	Kulite data storage array
AVG1	real	Average pressure across blade 1
AVG2	real	Average pressure across blade 2
AVG	real	Average pressure to be plotted
BP	real	Blade pair (1 - 9)
COC	real	Contraction ratio in flow meter
DATE	real	Calendar date yy.mmdd
DPNC	real	Flow meter differential pressure
GAIN	real	Amplifier gain of paced data
GO	integer	Index when plotter ready
G9	real	Ratio of specific heats (gamma)
IAVPLT	integer	Index to option for plotting
ICAL	integer	Index to option for on-line cal
ICON	integer	Index for plotting options
ICR	integer	Cartridge to store data files
IDCB(144)	integer	Data control block (buffer)
IDCBS	integer	Data control block size
IL	integer	Length of kulite data files
INAM(3)	integer	Name of kulite data files
IOPTN	integer	Return parameter from OPEN
IP(5)	integer	Parameters passed to "son" pgm
ISECU	integer	Security code to protect files
ISIZE(2)	integer	Size of kulite data files (records, words/record)
ISP	integer	OLC index for pneum. pressures
ITYPE	integer	Type of data files (Type 1)
JEND	integer	Total of points for calibration
JL	integer	Length of on-line cal data file
JNAM(3)	integer	Name of on-line cal data file

JSIZE(2)	integer	Size of O-1-C file (see ISIZE)
KL	integer	Length of plot program file
KNAM(3)	integer	Name of "son" program, WKPLT
KU(12)	real	Kulite numbers and A/D channels
KUNUM	real	Total number of kulites
MASK	binary	Logical mask to remove extra digits from acquired data
MFLC	real	Mass flow rate in compressor
N	integer	Number of pressure samples at each point to be averaged
NUM	integer	Number of graphs for plot page
OLCAL(2,256)	real	On-line calibration data array
PATM	real	Atmospheric pressure
PASS	integer	Label for additional data on same RUN of compressor
PLOTLU	integer	Logic unit for plot output 1--Terminal, 13--Plotter
PLT(256)	real	Data buffer sent to plot pgm
P1NC	real	Static pressure in flow meter
R	real	Gas constant for air
RO	real	Radius of flow meter throat (meters)
RPM	integer	Shaft angular velocity (RPM)
RUN	integer	Label of data files (TCR Run #)
SP	real	Pneumatic pressure colocated with Kulite tap
TAMB	real	Ambient temperature
TT	real	Total temperature

&WKAQN T=00004 IS ON CR00028 USING 00126 BLKS R=0000

```

0001 FTN4,L
0002 PROGRAM WKAQN (3,99)
0003 C *****
0004 C * TRANSONIC COMPRESSOR WALL-KULITE ACQUISITION * C
0005 C * THIS PROGRAM WAS WRITTEN FOR THE HP-21MX ACQUISITION COMPUTER * C
0006 C * AT THE NAVAL POSTGRADUATE SCHOOL TURBOPROPULSION LABRATORY * C
0007 C * TO ACQUIRE KULITE-PROBE PRESSURE DATA AT THE WALL OF THE ROTOR * C
0008 C * IN THE TRANSONIC COMPRESSOR , STORE THE DATA FOR REDUCTION, * C
0009 C * AND PLOT RAW DATA FOR A FIRST LOOK AT DEGREE OF SUCCESS. * C
0010 C * FOR A MORE COMPLETE EXPLANATION OF USE OF THIS PROGRAM, SEE * C
0011 C * CORNELL, NPS THESIS,1983. * C
0012 C * VER 7.0 10 AUG 83 DWC * C
0013 C ***** C
0014 C
0015 C -----DIMENSIONS AND INITIAL VALUES -----
0016 C
0017 REAL ARRAYA(4,256),OLCAL(2,256),PLT(256),KU(12)
0018 REAL PAT,PATM,TA,TAMB,MAX1,MIN1,AVG1,MAX2,MIN2,AVG2,MAX,MIN
0019 REAL TT,P1NC,DPNC,RO,AOC,COC,MFL,MFLC,R,G9,DATE,GAIN
0020 INTEGER RUN,PASS,ICAL,ICR,DEFLT,IAVPLT,PLOTLU,BP,N,RPM,GO,ICON
0021 INTEGER IP(5),INAM(3),JNAM(3),KNAM(3),ATOD(12),NUM,INUM,KUNUM,IGD
0022 INTEGER IDCBS(144), ISIZE(2),JSIZE(2),IL,JL,KL,IDCBS,ADCHNL,ISP
0023 C **** NOTA BENE **** PRIOR TO RUN OF PROGRAM, CORRECT DATA
0024 C IN THIS SECTION FOR KULITES AND CORRESPONDING A/D
0025 C CHANNELS. ALSO CHECK INAM EQUIVALENCES AT LINE
0026 C 85, (STATEMENT 200).
0027 DATA KU /6.0,7.0,7.5,8.0,8.5,9.0,9.5,10.0,10.5,11.0,12.0,13.0/
0028 DATA ATOD/ 2 , 3 , 4 , 5 , 6 , 7 , 8 , 9 , 10 , 11 , 12 , 13 /
0029 DATA KUNUM/12/,ICR/29/,GAIN/40.0/
0030 C
0031 DATA IDCBS/144/,ISECU/0/,ITYPE/1/,IL/2048/,JL/1024/,KL/512/
0032 DATA MASK/1777008/,INUM/1/
0033 DATA ISIZE/16,128/,JSIZE/8,128/,KNAM/2HWK,2HPL,2HT /
0034 DATA ARRAYA/1024*0.0/,OLCAL/512*0.0/,IP/5*0/,PLT/256*0.0/
0035 DATA COC/1.03/,R/287.06/,G9/1.402/
0036 C
0037 C ----- "100" ----- INPUT VALUES -----
0038 C
0039 WRITE(1,20)
0040 20 FORMAT("ENTER DATE....E.G. (YY.MMDD)")
0041 READ (1,*) DATE
0042 100 WRITE (1,101)
0043 101 FORMAT("ENTER RUN AND PASS NUMBERS .... E.G. (142,1)")
0044 READ (1,*) RUN,PASS
0045 WRITE (1,110)
0046 110 FORMAT("ENTER ATMOSPHERIC PRESSURE AS IN HG, AND",/,"PRESSURE",
0047 1 " " RATIO FROM STEADY STATE DATA..... E.G. (29.92,1.123)")
0048 READ (1,*) PA,PR
0049 PATM = PA * 13.57
0050 WRITE (1,120)
0051 120 FORMAT("IF ON LINE CALIBRATION DESIRED, ENTER (1) ")
0052 READ (1,*) ICAL
0053 WRITE (1,130)
0054 130 FORMAT("DO YOU WANT TO PLOT AVERAGE DATA?",/,"IF YES ENTER 1")
0055 READ (1,*) IAVPLT
0056 IF (IAVPLT .NE. 1) GO TO 200
0057 WRITE (1,140)
0058 140 FORMAT("ENTER LU# OF PLOTTING DEVICE: TERMINAL = 1",/,"

```



```

0059          1          "          PLOTTER = 13")
0060      READ (1,*) PLOTLU
0061      IF (PLOTLU .EQ. 1) GO TO 200
0062      WRITE(1,160)
0063  160      FORMAT("ENTER NUMBER OF PLOTS PER GRAPH (4 MAX)")
0064      READ (1,*) NUM
0065      IF ( NUM .GT. 4) NUM = 4
0066  C
0067  C ----- "200" ----- DEFINE DATA FILES -----
0068  C
0069  200      INAM(1) = 2HWK
0070          IF (PASS .EQ. 2 ) INAM(1) = 2HW2
0071          IF (PASS .EQ. 3 ) INAM(1) = 2HW3
0072          IF (PASS .EQ. 4 ) INAM(1) = 2HW4
0073          IF (PASS .EQ. 5 ) INAM(1) = 2HW5
0074          IF (PASS .EQ. 6 ) INAM(1) = 2HW6
0075          IF (PASS .EQ. 7 ) INAM(1) = 2HW7
0076          IF (PASS .EQ. 8 ) INAM(1) = 2HW8
0077          IF (PASS .EQ. 9 ) INAM(1) = 2HW9
0078          JNAM(1) = INAM(1)
0079          IF ( RUN .EQ. 146 ) INAM(2) = 2H46
0080          IF ( RUN .EQ. 147 ) INAM(2) = 2H47
0081          IF ( RUN .EQ. 148 ) INAM(2) = 2H48
0082          IF ( RUN .EQ. 99 ) INAM(2) = 2H99
0083      DO 290 I = 1,KUNUM
0084  210          IF (I .EQ. 1) INAM(3) = 2H01
0085              IF (I .EQ. 2) INAM(3) = 2H02
0086              IF (I .EQ. 3) INAM(3) = 2H03
0087              IF (I .EQ. 4) INAM(3) = 2H04
0088              IF (I .EQ. 5) INAM(3) = 2H05
0089              IF (I .EQ. 6) INAM(3) = 2H06
0090              IF (I .EQ. 7) INAM(3) = 2H07
0091              IF (I .EQ. 8) INAM(3) = 2H08
0092              IF (I .EQ. 9) INAM(3) = 2H09
0093              IF (I .EQ. 10) INAM(3) = 2H10
0094              IF (I .EQ. 11) INAM(3) = 2H11
0095              IF (I .EQ. 12) INAM(3) = 2H12
0096          CALL CREAT(IDCB,IERR,INAM,ISIZE,ITYPE,ISECU,ICR,IDCBS)
0097          JJ = 1
0098          IF( IERR .LT. 0 ) WRITE (1,990) JJ,IERR
0099          IF( IERR .NE. (-2) ) GOTO 230
0100          WRITE(1,220) INAM(2)
0101  220      FORMAT("FILENAME ",A2," ALREADY EXISTS!",/,
0102  1          "TO RENAME FILE, ENTER 1",/,," TO EXIT,          ,ENTER 0")
0103          READ(1,*) II
0104          CALL CLOSE(IDCB,IERR,0)
0105          IF ( II .EQ. 0 ) GOTO 900
0106          WRITE(1,225)
0107  225      FORMAT("ENTER NEW FILENAME.....(E.G. W24301)")
0108          READ(1,*) INAM
0109          GOTO 210
0110  230      IF( IERR .NE. (-33) ) GO TO 290
0111          WRITE(1,235) ICR,INAM
0112  235      FORMAT("NOT ENOUGH ROOM ON CARTRIDGE ",I3,". TO STORE"
0113  1          "FILE ",3A2,". ENTER ANOTHER MOUNTED CARTRIDGE.")
0114          READ(1,*) ICR
0115          CALL CLOSE(IDCB,IERR,0)
0116          GOTO 210
0117  290      CONTINUE
0118          JNAM(2) = 2HC1

```



```

0119      JNAM(3) = INAM(2)
0120      CALL CREAT(IDCIB,IERR,JNAM,JSIZE,ITYPE,ISECU,ICR,IDCBS)
0121      JJ = 5
0122      IF( IERR .LT. 0 ) WRITE (1,990) JJ,IERR
0123 C
0124 C ----- "300" ----- ON-LINE CALIBRATION
0125 C
0126      300 WRITE(6,301) DATE
0127      301 FORMAT(1H1,30X,"PROGRAM WKAQN -- ",F7.4,/)
0128      IF (ICAL .NE. 1) GO TO 400
0129      WRITE(6,310) RUN,ICAL
0130      310 FORMAT(25X," ON-LINE CALIBRATION OF WALL-KULITES",/,
0131      1 25X," RUN-",I3,10X," CALIBRATION NO. ",I1)
0132      CALL WKOLC (ICAL,OLCAL,KU,KUNUM)
0133      OLCAL(1,256) = FLOAT(RUN)
0134      OLCAL(1,255) = FLOAT(PASS)
0135      OLCAL(1,110) = PATM
0136      OLCAL(1,250) = DATE
0137      ICAL = 2
0138      RPM = OLCAL(1,103) * 10.0
0139      TT = OLCAL(1,106) * 1000.0 * 34.7279 + .6149
0140      TT = TT * 5./9. + 273.15
0141      P1NC = ( (OLCAL(1,82) - OLCAL(1,79) ) * 100000. + PATM ) * 249.0881
0142      DPNC = ( OLCAL(1,82) - OLCAL(1,83) ) * 100000. * 249.0881
0143      RO = 6.0 * 0.0254
0144      AOC = 3.141593 * (RO * RO)
0145      MFL = SQRT( ((2.0*(P1NC*DPNC))/R)/TT ) * 2.204634
0146      MFLC = MFL*(1.0 - ((( 3.0 * DPNC)/ 4.0 ) / G9) / P1NC))* (COC*AOC)
0147      OLCAL(1,251) = MFLC
0148      OLCAL(1,181) = KUNUM
0149      DO 320 I = 1,KUNUM
0150          OLCAL(1,181+I) = KU(I)
0151      320 CONTINUE
0152 C
0153 C ----- "400" ----- ACQUISITION ROUTINE (LOOP)
0154 C
0155      400 WRITE(1,405)
0156      405 FORMAT("WHEN READY TO ACQUIRE DATA.....ENTER 1")
0157      READ(1,*) GO
0158      IF ( GO .NE. 1 ) GOTO 400
0159      WRITE(6,410) DATE,RUN,PASS,RPM,MFLC,GAIN
0160      410 FORMAT(1H1,19X,"WALL-KULITE PRESSURE DATA FROM TCR USING WKAQN",
0161      1 /,5X,"DATE: ",F7.4,5X,"RUN NUMBER: ",I3,5X,"PASS NUMBER: ",I2,
0162      2 5X,F10.2,"RPM",5X,"MASS FLOW RATE: ",F10.7," LB/SEC",5X,
0163      3 "GAIN=",F4.1)
0164      WRITE (6,415)
0165      415 FORMAT("0",9X," KU CH FILE REP PAIR MAX1 MIN1 ",
0166      1 " AV1 MAX2 MIN2 AVG1 AVERAGE PNEU AVG",/,
0167      2 30X,"(PRESSURE IN INCHES H20)",//)
0168      OLCAL(1,224) = SCANR(08,39,01)
0169      OLCAL(1,225) = PATM
0170      DO 620 L=1,KUNUM
0171          WRITE(1,417)
0172      417 FORMAT("ENTER NO. SAMPLES AND BLADE PAIR..... E.G. (10,3)")
0173      READ (1,*) N,BP
0174      ADCHNL = ATOD(L)
0175      420 CALL WKPAC (ADCHNL,N,BP,ARRAYA)
0176      DO 430 I = 1,256
0177          PLT(I) = ARRAYA(1,I)
0178      430 CONTINUE

```



```

0179      CALL XTREM(PLT,MAX1,MAX2,MIN1,MIN2,AVG1,AVG2,GAIN)
0180      AVG = (AVG1 + AVG2) / 2.0
0181  C
0182  C ----- "500" ----- PLOT AVERAGE DATA -----
0183  C
0184      500      IF (IAVPLT .NE. 1) GO TO 600
0185              MAX = MAX1
0186              IF (MAX2 .GT. MAX ) MAX = MAX2
0187              MIN = MIN1
0188              IF (MIN2 .LT. MIN ) MIN = MIN2
0189              ICODE = 9 + 100000B
0190              IP(2) = PLOTLU
0191              IP(3) = INUM
0192              IP(4) = ADCHNL-1
0193              CALL EXEC(ICODE,KNAM,IP(1),IP(2),IP(3),IP(4),IP(5),PLT,KL)
0194              GO TO 800
0195  C
0196      530      CALL RMPAR (IP)
0197              IF ( IP(1) .EQ. 100000B ) WRITE (1,540)
0198      540      FORMAT ( "&WKPLT TERMINATED ABNORMALLY!" )
0199              ICODE = 14 + 100000B
0200              CALL EXEC(ICODE,1,PLT,KL)
0201              GOTO 800
0202      550      INUM = INUM + 1
0203              IF ( INUM .GT. NUM ) INUM = 1
0204              WRITE( 1,560) PLOTLU
0205      560      FORMAT("CHOOSE ONE OF THE FOLLOWING: ",/,
0206      1          "PLOT LU# IS ",I2,".",/,
0207      2          "A. IF DATA LOOKS SATISFACTORY,          ENTER 1"
0208      3          ,/, "B. IF YOU WANT TO RETAKE THIS POINT,    ENTER 0"
0209      4          ,/, "C. IF YOU WANT TO CHANGE PLOT DEVICE, AND..."
0210      5          ,/, "      1) DATA LOOKS SATISFACTORY,      ENTER -1"
0211      6          ,/, "      2) YOU WANT TO RETAKE DATA,        ENTER -2"
0212      7          ,/, "D. IF NO MORE PLOTS DESIRED (EXIT)    ENTER 2" )
0213              READ (1,*) ICON
0214              IF (ICON .EQ. 2) IAVPLT = 0
0215              IF (ICON .GE. 0) GO TO 590
0216              IF (PLOTLU .EQ. 1) GO TO 570
0217              PLOTLU = 1
0218              NUM = 1
0219              GO TO 590
0220      570      PLOTLU = 13
0221              WRITE (1,580)
0222      580      FORMAT("ENTER THE NUMBER OF PLOTS ALREADY ON THE PLOTTER "
0223      1          ,/, "(IF 0 OR 4, ENTER 0)" )
0224              READ (1,*) INUM
0225              INUM = INUM + 1
0226              WRITE (1,160)
0227              READ (1,*) NUM
0228      590      IF ( IABS(ICON) .EQ. 1) GO TO 600
0229              DO 593 I = 1,4
0230                  DO 592 J = 1,256
0231                      ARRAYA(I,J) = 0.0
0232      592      CONTINUE
0233      593      CONTINUE
0234              WRITE(1,417)
0235              READ(1,*) N,BP
0236              GO TO 420
0237  C
0238  C ----- "600" ----- STORE DATA FILES -----

```



```

0239 C
0240 600 IF ( L .EQ. 1 ) INAM(3) = 2H01
0241 IF ( L .EQ. 2 ) INAM(3) = 2H02
0242 IF ( L .EQ. 3 ) INAM(3) = 2H03
0243 IF ( L .EQ. 4 ) INAM(3) = 2H04
0244 IF ( L .EQ. 5 ) INAM(3) = 2H05
0245 IF ( L .EQ. 6 ) INAM(3) = 2H06
0246 IF ( L .EQ. 7 ) INAM(3) = 2H07
0247 IF ( L .EQ. 8 ) INAM(3) = 2H08
0248 IF ( L .EQ. 9 ) INAM(3) = 2H09
0249 IF ( L .EQ. 10 ) INAM(3) = 2H10
0250 IF ( L .EQ. 11 ) INAM(3) = 2H11
0251 IF ( L .EQ. 12 ) INAM(3) = 2H12
0252 CALL OPEN(IDCB,IERR,INAM,IOPTN,ISECU,ICR,IDCBS)
0253 JJ = 2
0254 IF ( IERR .LT. 0 ) WRITE (1,990) JJ,IERR
0255 CALL WRITF(IDCB,IERR,ARRAYA,IL)
0256 JJ = 3
0257 IF ( IERR .LT. 0 ) WRITE (1,990) JJ,IERR
0258 CALL CLOSE(IDCB,IERR,0)
0259 JJ = 4
0260 IF ( IERR .LT. 0 ) WRITE (1,990) JJ,IERR
0261 ISP = ATOD(L) + 88
0262 IF ( L .GT. 10 ) ISP = ISP + 1
0263 SP = OLCAL(1,ISP) * 100000.0
0264 WRITE(6,610) KU(L),ATOD(L),INAM,N,BP,MAX1,MIN1,AVG1,
0265 1 MAX2,MIN2,AVG2,AVG,SP
0266 610 FORMAT(10X,F4.1,I4,1X,3A2,I5,F5.1,8(3X,F6.1),/)
0267 620 CONTINUE
0268 OLCAL(1,254) = BP
0269 OLCAL(1,253) = N
0270 OLCAL(1,194) = GAIN
0271 OLCAL(2,224) = SCANR(08,39,01)
0272 OLCAL(2,225) = PATM
0273 C
0274 C ----- "700" ----- ON-LINE CALIBRATION -----
0275 C
0276 700 IF ( ICAL .NE. 2 ) GO TO 750
0277 WRITE (6,702)
0278 702 FORMAT(1H1)
0279 WRITE(6,310) RUN,ICAL
0280 CALL WKOLC (ICAL,OLCAL,KU,KUNUM)
0281 ICAL = 1
0282 CALL OPEN(IDCB,IERR,JNAM,IOPTN,ISECU,ICR,IDCBS)
0283 JJ = 6
0284 IF( IERR .LT. 0 ) WRITE(1,990) JJ,IERR
0285 CALL WRITF(IDCB,IERR,OLCAL,JL)
0286 JJ = 7
0287 IF( IERR .LT. 0 ) WRITE(1,990) JJ,IERR
0288 CALL CLOSE(IDCB,IERR,0)
0289 JJ = 8
0290 IF( IERR .LT. 0 ) WRITE(1,990) JJ,IERR
0291 C
0292 750 WRITE (1,760)
0293 760 FORMAT(" ONE PASS IS COMPLETE, IF YOU WANT TO CONTINUE:",/,
0294 1 "ENTER 1.....TO EXIT ENTER 0")
0295 READ(1,*) IGO
0296 PASS = PASS + IGO
0297 IF ( IGO .NE. 0 ) GO TO 100
0298 GOTO 900

```



```

0299 C
0300 C ----- "800" ----- ERROR PROCESSING SECTION -----
0301 C
0302 800 CALL ABREG(IA,IB)
0303 WRITE (1,810) IA,IB
0304 810 FORMAT("ERROR RETURNED FROM EXEC ",I3,"CALL:")
0305 1 ,/, " A-REGISTER = ",I6," (ASCII CODE FOR ERROR TYPE)"
0306 2 ,/, " B-REGISTER = ",I6," (ASCII CODE FOR ERROR NUMBER)"
0307 IF (ICODE .EQ. 9) GO TO 530
0308 GO TO 550
0309 900 STOP
0310 990 FORMAT("ERROR FROM ",I3, " ERROR # : ",I4)
0311 C ----- "1000" ----- END MAIN WKAQN
0312 END
0313 C *****

```


A.3 SUBROUTINE--WKOLC

A.3.1 Description of WKOLC

The subroutine WKOLC is used to perform the on-line calibration. An on-line calibration is conducted prior to and after unsteady pressure data acquisition to establish the correct pressure versus voltage relationship produced by the Kulite transducers. This relationship is linear as demonstrated by Paige [Ref. 7]. Although linear, the slope and absolute magnitude of the pressure-voltage curve changes with temperature. Thus a calibration must be made while the transducer is at the same temperature at it is for the acquisition of unsteady pressure data. Thus, calibration is conducted just prior to data acquisition as well as just after acquisition to ensure that this relationship does not change during the acquisition.

The static pressure measured by a Kulite transducer is really a difference between the actual static pressure in the compressor and a reference pressure, PKR, applied on the back of the Kulite diaphragm (Fig. 4). At a given temperature, the unsteady pressure-voltage relationship can be represented by:

$$P = A_0 + A_1 \cdot e + PKR \quad (A3-1)$$

Solving for Kulite voltage:

$$e = -A_0/A_1 + 1/A_1 \cdot P - 1/A_1 \cdot P_{av} \quad (A3-2)$$

If the static pressure is constant, the first two terms can be combined into a single constant of the form:

$$K2 = -A0/A1 + 1/A1 P_{av} \quad (A3-3)$$

Then equation A3-2 becomes:

$$e = K2 + K1 \cdot PKR \quad (A3-4)$$

where $K1 = -1/A1$. The Kulite reference pressure, PKR , can be set and the corresponding Kulite voltage, e , can be recorded. Then a different PKR is applied and its corresponding voltage is recorded. The result is set of data points which can be plotted and a linear curve-fitting routine can be applied to determine the actual slope and intercept. The method used was a least-squares curve fitting procedure. Since each Kulite behaves a little differently, a slope and intercept is recorded for each one.

The temperature is assumed constant since the whole process takes only a few seconds. Although the static pressure is changing continuously, a time averaged static pressure remains constant at each wall location. As described in chapter 2, the voltage read through the digital voltmeter is essentially an average pressure. The pneumatic ports have been calibrated to be very precise, therefore, they are assumed correct and the kulite average pressure is biased to agree with the pneumatic. The pressure P_{av} and PKR are known for several corresponding voltages, (up to six) and thus $A1$ and $A0$ are known for each kulite. The kulite reference pressure is then set at a specific value, (usually atmospheric pressure), then for any Kulite voltage recorded,

a corresponding accurate pressure can be obtained using equation (A3-1). (See Figure A-1)

The function SCANR is used to select scanner channels and read the values from either the DVM or the counter. The arguments of the function are the logic unit of the scanner, the scanner channel, and the instrument code.

(1=DVM, 2=counter)

After the calibration points are recorded, steady state pneumatic pressures and flow parameters are recorded. The function ACQN is used to select and read the scanivalves which measure the pressures at the pneumatic ports. The arguments include the scanivalve number, scanivalve port number, and time delay factor. The port assignments are listed in Table III of the main report.

The flow data are converted to common units for output to the printer. Specific conversions are discussed in section A.2.

The subroutine section "400" converts slopes, $-K_1$, and intercepts, K_2 , to A_1 and A_0 which are used in equation A3-1. The variable zero is correction obtained by reading the output of the transducer when equal pressure is applied to both sides. The resulting differential output, which should be zero, is subtracted from all scanivalve measurements. As before, the scaling factor 100000.0 is

applied to pneumatic measurements and 10000.0 is applied to Kulite measurements.

The values of the slopes and intercepts are stored in the OLCAL array and the array is returned to the main program.

A.3.2 Nomenclature for Subroutine WKOLC

A0	real	E=0 intercept of P-e curve
A1	real	E=0 slope of p-e curve
DT00	real	Temperature at flow nozzle
DTA4	real	Temperature
DTB4	real	Temperature
DTC4	real	Temperature
DUM	real	Dummy variable
E(12)	real	Kulite voltage
GO	integer	Index to commence calibration
ICAL	integer	Identifies calibration =1 before, =2 after
INCPT(12)	integer	Array of A0 intercepts
INDEX	integer	Increments column number for printout
I150	integer	Changes A/D channel (2-13) to Kulite number (1-12)
I155	integer	Identifies scanner channel
I175	integer	Identifies column number in OLCAL
I410	integer	Column number of PKR's
I420	integer	Column number of each Kulite voltage read for each PKR in I410
JEND	integer	Total of points for calibration
K0	real	P=0 intercept of P-e curve
K1	real	Slope of curve-fit, $K1 = -1/A1$
K2	real	Intercept of curve-fit
KU(12)	real	Kulite transducer channels
KUNUM	integer	Total of Kulites (usually 12)
OLCAL(2,256)	real	Data array for calibration, steady state and flow measure- ments
Pav	real	Average pressure
PKR(6)	real	Kulite reference pressure
P1NC	real	Pressure into flow nozzle
P2NC	real	Pressure out of flow nozzle

PT00	real	Total pressure in tunnel
SLOPE(12)	real	Array of a1 slopes
SUMDUM	real	Summer for PKR averaging
SUM1-5	real	Summer for temperature averaging
TT	real	Total temperature
ZERO	real	Pa-Pa differential on scanivalve

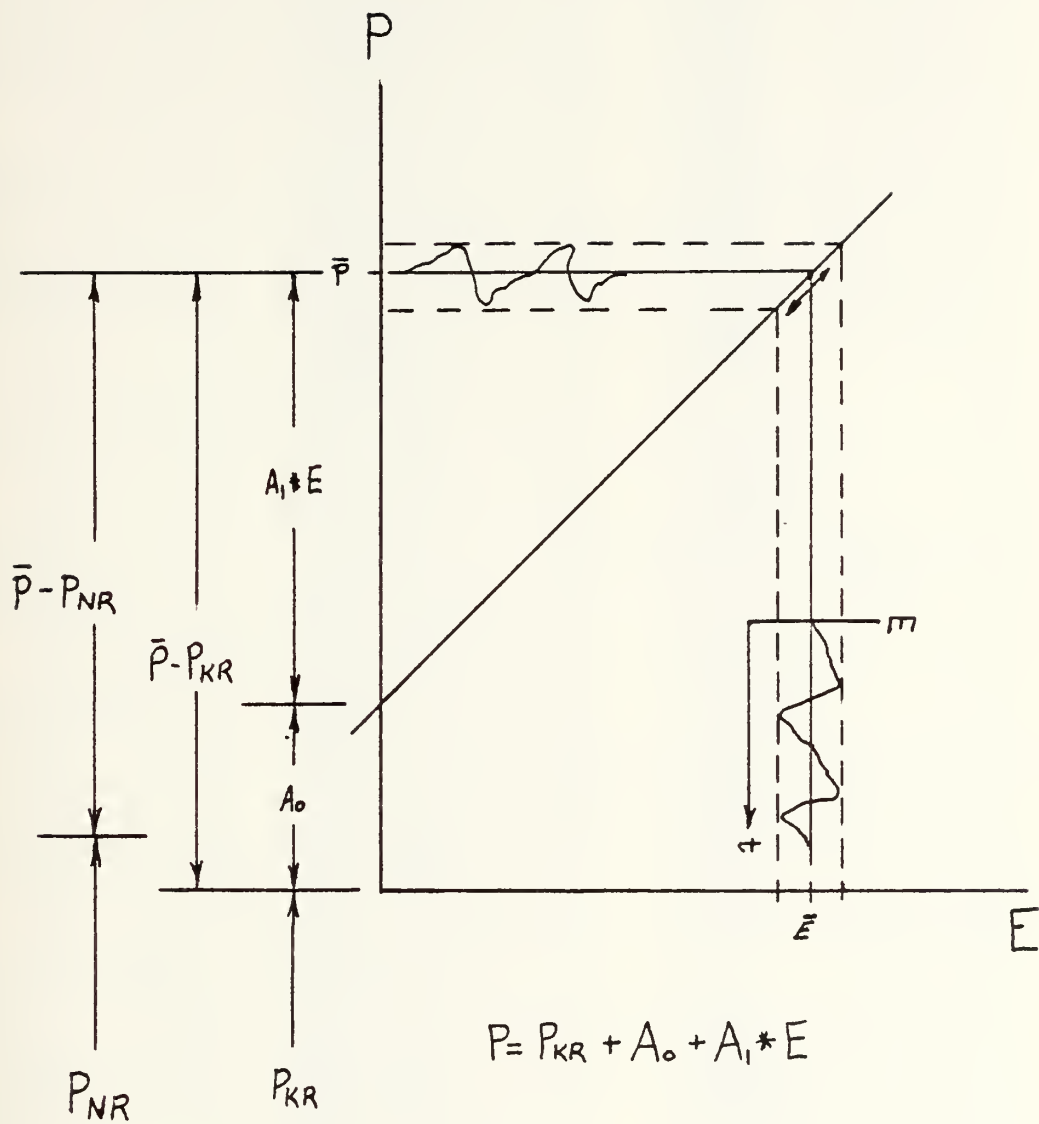


Figure A.2 Pressure-Kulite Voltage Relationship

&WKAQN T=00004 IS ON CR00028 USING 00126 BLKS R=0000

```

0313 C *****
0314 SUBROUTINE WKOLC(ICAL,OLCAL,KU,KUNUM)
0315 C * WALL-KULITE ON-LINE CALIBRATION *
0316 C * PROGRAM USED FOR CALIBRATING KULITE PRESSURE TRANSDUCERS *
0317 C * BY DETERMINING THE SLOPE AND INTERCEPT OF THE PRESSURE VS. *
0318 C * KULITE VOLTAGE CURVE USING REFERENCE PRESSURES SET BY THE *
0319 C * TECHNICIAN. FOR MORE COMPLETE INFORMATION, SEE THESIS BY *
0320 C * CORNELL, 1983. *
0321 C * VER 7.0 10 AUG 1983 DWC *
0322 C*****
0323 C
0324 C DECLARATIONS/DIMENSIONS
0325 C
0326 REAL OLCAL(2,256),PKR(6),E(6),ZERO,SLOPE(12),SUMDUM,DUM,A0,A1
0327 REAL INCPT(12),K1,K2,K0,KU(12),SUM1,SUM2,SUM3,SUM4,SUM5
0328 REAL TT,DT00,DTA4,DTB4,DTC4,P1NC,P2NC,PT00
0329 INTEGER JEND,GO,ICAL,KUNUM,IWK,INDEX
0330 C
0331 C INITIALIZE ARRAY
0332 C
0333 IF (ICAL .EQ. 2 ) GO TO 100
0334 DO 20 I=1,2
0335 DO 10 J=1,256
0336 OLCAL(I,J)=0.0
0337 10 CONTINUE
0338 20 CONTINUE
0339 C
0340 C----- "100" -----TAKE REFERENCE PRESSURES AND
0341 C WALL-KULITE PRESSURE DATA
0342 C
0343 100 WRITE(1,105)
0344 105 FORMAT("HOW MANY CALIBRATION POINTS WILL YOU USE? (6 IS MAX)")
0345 READ(1,*) JEND
0346 OLCAL(1,81) = FLOAT(JEND)
0347 INDEX = 1
0348 DO 160 J = 1,JEND
0349 110 WRITE(1,112) J
0350 112 FORMAT("WAIT UNTIL CAL PRESSURE ",I1," IS SET, THEN ENTER 1 ",
0351 1 /,"TO EXIT CALIBRATION ROUTINE, ENTER 0 ")
0352 READ(1,*) GO
0353 IF ( GO .EQ. 0) GOTO 500
0354 IF ( GO .NE. 1 ) GOTO 110
0355 CALL ABRT(7,2)
0356 CALL RMOTE(8)
0357 CALL RMOTE(10)
0358 CALL RMOTE(12)
0359 CALL RMOTE(15)
0360 WRITE(8,120)
0361 120 FORMAT("CA")
0362 WRITE(10,130)
0363 130 FORMAT("F1R7M3A1H0T3")
0364 WRITE(12,140)
0365 140 FORMAT("PF4G6T")
0366 WRITE(15,120)
0367 C KULITE REFERENCE PRESSURE
0368 C SCANNER #1, CHANNEL 39
0369 SUMDUM = 0.0
0370 DO 142 I = 1,5

```



```

0371      DUM = SCANR(08,39,01)
0372      SUMDUM = SUMDUM + DUM
0373 142    CONTINUE
0374      OLCAL(ICAL,INDEX) = SUMDUM / 5.0
0375      WRITE(6,145) J, OLCAL(ICAL,INDEX)
0376      INDEX = INDEX + 1
0377 145    FORMAT(//,24X,"CAL POINT -",I1,"- KU REF PRESS =",F9.6,/,34X,
0378 1        "KULITE VOLTAGES",/,30X,"KULITE",13X,"VOLTS")
0379 C
0380 C
0381 C      WALL KULITE TRANSDUCERS
0382 C      SCANNER #2, CHNLS 40 TO 51
0382      DO 155 I=2,13
0383      I155=I+38
0384      SUMDUM = 0.0
0385      DO 150 K = 1,5
0386      DUM = SCANR(15,I155,01)
0387      SUMDUM = SUMDUM + DUM
0388 150    CONTINUE
0389      OLCAL(ICAL,INDEX) = SUMDUM / 5.0
0390      I150 = I - 1
0391      WRITE(6,151) KU(I150), OLCAL(ICAL,INDEX)
0392 151    FORMAT(30X,F4.1,12X,F9.6)
0393      INDEX = INDEX + 1
0394 155    CONTINUE
0395 160    CONTINUE
0396 C      TARES (PA - PA), (PCAL- PA)
0397 C      SCANIVALVE #1, PORTS 1 + 2
0398      OLCAL(ICAL,79)= ACQN(01,01,25)
0399      OLCAL(ICAL,80)= ACQN(01,02,25)
0400      WRITE(6,165) OLCAL(ICAL,79), OLCAL(ICAL,80)
0401 165    FORMAT(1X,/,17X,"TARE SV#1 =",F9.6,10X,"PCAL - PA =",F9.6,
0402 1        //,27X,"PNEUMATIC PRESSURES - S1 TO S13",/,37X,"VOLTS",/)
0403 C      COMPRESSOR NOZZLE P1 & P2
0404 C      SCANIVALVE #1, PORTS 3 + 4
0405      OLCAL(ICAL,82) = ACQN(01,03,25)
0406      OLCAL(ICAL,83) = ACQN(01,04,25)
0407 C      STAGNATION PRESSURE
0408 C      SCANIVALVE #1,PORTS 5
0409      OLCAL(ICAL,84) = ACQN(01,05,25)
0410 C      PNEUMATIC PRESSURES S1 TO S13
0411 C      INCLUDING 7.5,8.5,9.5,10.5+11.5
0412      DO 175 I=6,23
0413      I175=I+79
0414      OLCAL(ICAL,I175) = ACQN(01,I,25)
0415      WRITE(6,170) OLCAL(ICAL,I175)
0416 170    FORMAT(35X,F9.6)
0417 175    CONTINUE
0418 C
0419 C ----- "200" ----- ACQUIRING REMAINING OLC DATA
0420 C
0421 C      RPM & BLADE FREQUENCY
0422 C      SCANNER #1, CHANNELS 17 + 19
0423      OLCAL(ICAL,103) = SCANR(08,17,02)
0424      OLCAL(ICAL,104) = SCANR(08,19,02)
0425 C      COMPRESSOR TEMPERATURES
0426 C      SCANNER #2 , CHANNELS 4,6,14-16
0427      SUM1 = 0.0
0428      SUM2 = 0.0
0429      SUM3 = 0.0
0430      SUM4 = 0.0

```



```

0431      SUM5 = 0.0
0432      DO 250 I = 1,5
0433          DUM = SCANR(15,04,01)
0434          SUM1 = SUM1 + DUM
0435          DUM = SCANR(15,06,01)
0436          SUM2 = SUM2 + DUM
0437          DUM = SCANR(15,14,01)
0438          SUM3 = SUM3 + DUM
0439          DUM = SCANR(15,15,01)
0440          SUM4 = SUM4 + DUM
0441          DUM = SCANR(15,16,01)
0442          SUM5 = SUM5 + DUM
0443 250 CONTINUE
0444      OLCAL(ICAL,105) = SUM1 / 5.0
0445      OLCAL(ICAL,106) = SUM2 / 5.0
0446      OLCAL(ICAL,107) = SUM3 / 5.0
0447      OLCAL(ICAL,108) = SUM4 / 5.0
0448      OLCAL(ICAL,109) = SUM5 / 5.0
0449  C
0450  C ----- "300" ----- PRINTING FLOW DATA
0451      RPM = OLCAL(ICAL,103) * 10.
0452      TT = ( OLCAL(ICAL,105) * 1000. * 34.7279 + .6149 ) * 5./9. + 273.15
0453      DT00 = OLCAL(ICAL,106) * 1000. * 34.7279 + .6149 * 5./9. + 273.15
0454      DTA4 = OLCAL(ICAL,107) * 1000. * 34.7279 + .6149 * 5. / 9. + 273.15
0455      DTB4 = OLCAL(ICAL,108) * 1000. * 34.7279 + .6149 * 5./9. + 273.15
0456      DTC4 = OLCAL(ICAL,109) * 1000. * 34.7279 + .6149 * 5./9. + 273.15
0457      P1NC = ( OLCAL(ICAL,82) - OLCAL(ICAL,79) ) * 100000. + PATM
0458      P2NC = ( OLCAL(ICAL,83) - OLCAL(ICAL,79) ) * 100000. + PATM
0459      PT00 = ( OLCAL(ICAL,84) - OLCAL(ICAL,79) ) * 100000. + PATM
0460      WRITE(6,310) RPM,OLCAL(ICAL,104),TT,DTA4,DT00,DTB4,DTC4
0461 310  FORMAT(1X,/,22X,"RPM =",F8.2,5X,"BLADE FREQUENCY =",F6.1,/,/,
0462      1 30X,"COMPRESSOR TEMPERATURES",/,35X,"DEGREES KELVIN",/,
0463      2 20X,"T1 - NC =", F7.3,
0464      3 5X,"DEL T A4 =",F7.3,/,20X,"DELTA T00 =",F7.3,5X,
0465      4 "DEL T B4 =",F7.3,/,43X,"DEL T C4 =",F7.3,/)
0466      WRITE(6,320) P1NC,P2NC,PT00
0467 320  FORMAT(32X,"COMPRESSOR PRESSURES",/,33X,"(INCHES OF WATER)",/,
0468      1 32X,"P1-PA =",F7.3,/,32X,
0469      1 "P2-PA =",F7.3,/,32X,"PT00 =",F7.3)
0470  C
0471  C----- "400" ----- CALCULATION FOR DETERMINING SLOPE
0472  C AND INTERCEPT OF PRESSURE VS KULIT
0473  C CURVE--( A0,A1 )
0474 400 DO 490 K = 1,KUNUM
0475      DO 430 J = 1,JEND
0476          ZERO = OLCAL(ICAL,79)
0477          I410 = (J-1)*13 + 1
0478          PKR(J) = ( OLCAL(ICAL,I410) - ZERO ) * 100000.0
0479          I420 = (J-1)*13 + 1 + K
0480          E(J) = OLCAL(ICAL,I420) * 10000.0
0481 430 CONTINUE
0482      CALL CURFT(JEND,PKR,E,K1,K2)
0483  C
0484  C CHANGE INCPT TO A0, SLOPE TO A1
0485      IF ( K .EQ. 11 ) I = 101
0486      IF ( K .EQ. 12 ) I = 102
0487      IF ( K .LT. 11 ) I = K + 89
0488      PAV = ( OLCAL(ICAL,I) - ZERO ) * 100000.0
0489      K0 = K2 - K1 * PAV
0490      A1 = - 1.0 / K1

```



```

0491      A0 = -K0 * A1
0492      SLOPE(K) = A1
0493      INCPT(K) = A0
0494      WRITE(6,495) KU(K), SLOPE(K), INCPT(K)
0495  490  CONTINUE
0496  495  FORMAT(10X," KULITE NO.",F5.1,SX,"SLOPE A1 =",F6.3,SX,
0497        1  "INTERCEPT A0 =",F6.3,/)
0498  C
0499  C----- "500" ----- STORE SLOPES,INTERCEPTS AND END
0500  500  DO 520 I=1,KUNUM
0501        IS20 = 225 + I
0502        IS25 = 237 + I
0503        OLCAL(ICAL,225+I) = SLOPE(I)
0504        OLCAL(ICAL,237+I) = INCPT(I)
0505  520  CONTINUE
0506      RETURN
0507  C ----- END OF SUBROUTINE &WKOLC -----
0508      END
0509  C ***** C

```


A.4 SUBROUTINE--CURFT

A.4.1 Description of CURFT

This subroutine is called by WKOLC to calculate the slope and intercept of a line fit through the calibration points of Kulite voltage, e , and reference pressure, PKR . The method of least squares is used to fit the curve.

[Ref. 21]

The object of the curve fitting is to minimize the distance between the data points and the corresponding points on the line. The least squares criterion minimizes the sum of the squares of the distances $(e - e')$ for each PKR . (See Figure A.4)

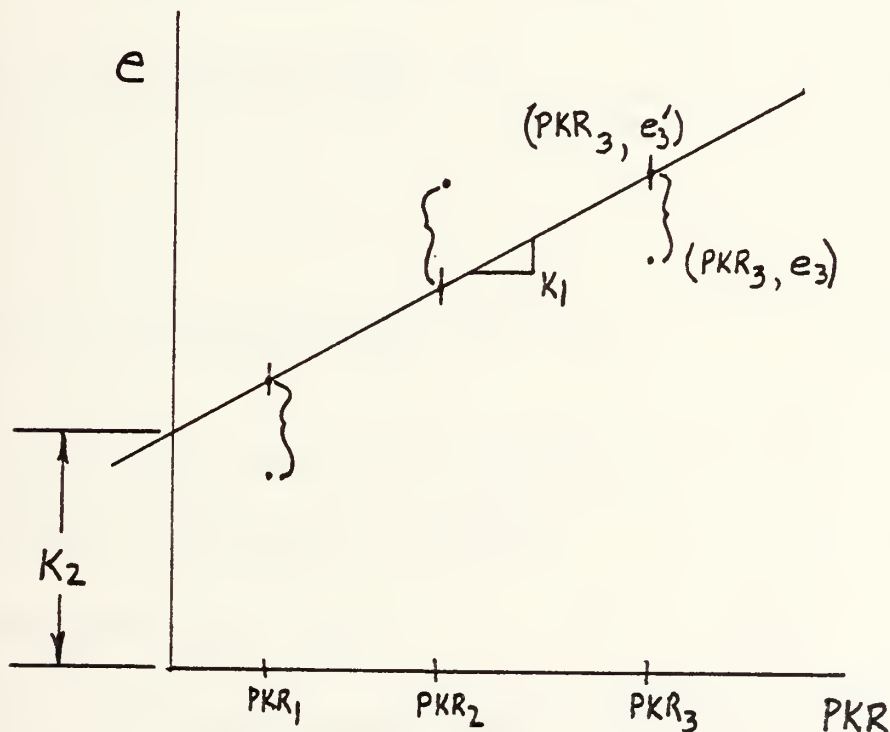


Figure A.4 Least Squares Scheme

The sum to be minimized can be written:

$$S = \sum_{i=1}^J (e_i - e'_i)^2 \quad (\text{A4-1})$$

where J is the total number of data points. Using the relationship between Kulite voltage and PKR from equation (A3-3), the sum becomes:

$$S = \sum_{i=1}^J (e_i - K_2 + K_1 \cdot \text{PKR}_i) \quad (\text{A4-2})$$

The minimum is found by differentiating the equation partially with respect to K_1 and then K_2 , and setting each partial derivative equal to zero, thus:

$$\frac{\partial S}{\partial K_1} = 2 \sum_{i=1}^J (e_i - K_2 + K_1 \cdot \text{PKR}_i) = 0 \quad (\text{A4-3a})$$

and

$$\frac{\partial S}{\partial K_2} = 2 \sum_{i=1}^J (e_i - K_2 + K_1 \cdot \text{PKR}_i)(-1) = 0 \quad (\text{A4-3b})$$

The resulting equations are simplified to:

$$(\sum \text{PKR}_i^2)K_1 + (\sum \text{PKR}_i)K_2 = \sum e_i \cdot \text{PKR}_i \quad (\text{A4-4a})$$

$$(\sum \text{PKR}_i)K_1 + J \cdot K_2 = \sum e_i \quad (\text{A4-4b})$$

These equations can be solved simultaneously for K_1 and K_2 with the following results:

$$\text{slope } K_1 = \frac{J(\sum(PKR_i - e_i)) - \sum PKR_i \sum e_i}{J \cdot \sum(PKR_i)^2 - (\sum PKR_i)^2} \quad (A4-5a)$$

$$\text{intercept } K_2 = \frac{\sum e_i - \sum PKR_i \cdot K_1}{J} \quad (A4-5b)$$

A.4.2 Nomenclature & Listing for Subroutine CURFT

E(6)	real	Kulite voltages
FJEND	real	Floating point value of JEND
JEND,J	integer	Number of calibration points
K1	real	Slope of curve-fit
K2	real	Intercept of curve-fit
PKR(6)	real	Kulite reference pressure
SUMKV	real	Summer for Kulite voltages
SUMPR	real	Summer for reference pressures
SUMXX	real	Sum of PKR's squared
SUMXY	real	Sum of (PKR * e)'s

AWKAQN T=00004 IS ON CR00028 USING 00126 BLKS R=0000

```

0509 C ***** C
0510 SUBROUTINE CURFT(JEND,PKR,E,K1,K2)
0511 C * USED WITH WKOLC TO CALCULATE SLOPE AND INTERCEPTS FOR WALL * C
0512 C * KULITE ON-LINE-CAL. USES LEAST SQUARES APPROXIMATION * C
0513 C * 1 AUG 1983 DWG * C
0514 C ***** C
0515 C *
0516 C DIMENSIONS
0517 REAL PKR(6),E(6),K1,K2,FJEND
0518 INTEGER JEND
0519 C INITIAL VALUES
0520 SUMPR = 0.0
0521 SUMKV = 0.0
0522 SUMXY = 0.0
0523 SUMXX = 0.0
0524 C SUMMATIONS
0525 DO 20 I = 1,JEND
0526 SUMPR = SUMPR + PKR(I)
0527 SUMKV = SUMKV + E(I)
0528 SUMXY = SUMXY + PKR(I) * E(I)
0529 SUMXX = SUMXX + PKR(I) * PKR(I)
0530 20 CONTINUE
0531 C CALCULATION OF SLOPE
0532 FJEND = FLOAT(JEND)
0533 K1 = ((FJEND*SUMXY - SUMKV*SUMPR)/(FJEND*SUMXX - SUMPR*SUMPR))
0534 K2 = (SUMKV - SUMPR * K1) / FJEND
0535 RETURN
0536 END
0537 C ***** C

```


A.5 SUBROUTINE--WKPAC

A.5.1 Description of WKPAC

This subroutine, an adaptation of the subroutine RPACE by McCarville [Ref. 11], triggers the A/D converter at the correct time to read the Kulite voltages. The number of counts delay (IBLADE) from the 1 per rev reset pulse is set to account for the blade pair selected, the one-to-256 blade-to-blade position, the physical location of the Kulite transducers in the case wall, and the initial delay from the optical trigger to the first blade pair. The actual software drivers for the PACER and A/D are hidden in the EXEC library routines. The use of drivers can be found in McCarville or the Hewlett-Packard Reference Manuals. [Ref. 22, Ref. 23]

The first subroutine, EXEC(3,19), clears the PACER. The next, EXEC(1,19,IRPM,1,IBLADE), passes the value of IBLADE to the PACER and reads the frequency counter in the PACER for the number of computer clock pulses between one-per-rev triggers. The output, IRPM, is not a direct measure of the speed of the compressor but must be divided into by 15×10 to obtain units of RPM. Therefore, RPM is reqd directly from a magnetic pulse counter. However, this call is necessary for the next EXEC to work.

The last call, EXEC(1,10,IBUFF,N,ADCHL,0), is the routine that selects the identified A/D channel and reads the N data samples at the location specified by IBLADE.

When the three values of the sample set calculated by WKRMS and the sample set average are stored in ARRAYA, the procedure is repeated for each of the 256 locations.

2.5.2 Nomenclature & Listing for Subroutine WKPAC

ADCHL	integer	A/D channel number
ARRAYA(4,256)	real	Array of unsteady Kulite data
BP	integer	Blade pair selected
IBLADE	integer	Delay parameter to trigger A/D
IBUFF(99)	integer	Buffer array for N samples
IKON	binary	Sets no abort bit
IO	integer	Initial delay from one-per-rev trigger to first blade pair
IOFFS	integer	Delay added for transducer location
IRPM	integer	Counts between one-per-rev triggers
MASK	binary	Used to eliminate non-signifi- cant figures coded by A/D
MAX	real	Maximum value of sample set
MIN	real	Minimum value of sample set
N	integer	Number of Kulite samples taken at each of the 256 blade-to- blade locations
RMS	real	Root-mean-square value of sample set
SAMP(99)	real	Floating point array of samples
SUMPR	real	Sum of samples

AWKAQN T=00004 IS ON CR00028 USING 00126 BLKS R=0000

```

0537 C ***** C
0538 SUBROUTINE WKPAC(ADCHL,N,BP,ARRAYA)
0539 C USED WITH WKAQN TO ACQUIRE WALL-KULITE DATA ON THE TRANSONIC C
0540 C COMPRESSOR. FOR MORE, SEE CORNELL, NPS THESIS, 1983. C
0541 C VER 3.0 19 JUL 1983 DWC C
0542 C ***** C
0543 C
0544 C DIMENSIONS
0545 C
0546 C INTEGER ADCHL,IBLADE,BP,PLOTLU,IOFFS,N,IBUFF(99),IO
0547 C REAL ARRAYA(4,256),SUMPR,SAMP(99)
0548 C REAL MAX,MIN,RMS
0549 C
0550 C ----- "100" ----- DATA AND INITIAL VALUES
0551 C
0552 C DATA MASK/177700B/
0553 C DATA IOFFS/0/
0554 C DATA IKON/100000B/
0555 C
0556 C VALUE OF IOFFS TRIGGER CORRECT POSITION OF KULITES
0557 C TO ENSURE MEASUREMENTS BEHIND SAME BLADE ROW.
0558 C IO INDICATES THE DIFFERENCE FROM A PROBE TO THE
0559 C WALL KULITE MEASUREMENT PLANE.
0560 C IO = 256
0561 C IOFFS = IO
0562 C IF ( ADCHL .EQ. 6 .OR. ADCHL .EQ. 10 ) IOFFS = IO + 640
0563 C IF ( ADCHL .EQ. 4 .OR. ADCHL .EQ. 8 ) IOFFS = IO + 576
0564 C IF ( ADCHL .EQ. 3 .OR. ADCHL .EQ. 7 ) IOFFS = IO + 64
0565 C IF ( ADCHL .EQ. 11 .OR. ADCHL .EQ. 13 ) IOFFS = IO + 64
0566 C
0567 C ----- "200" ----- ACQUISITION
0568 C 200 CONTINUE
0569 C DO 250 J = 0,255
0570 C IBLADE= 256*( BP-1) + J + IOFFS + IKON
0571 C CALL EXEC (3,19)
0572 C CALL EXEC (1,19,IRPM,1,IBLADE)
0573 C CALL EXEC (1,20,IBUFF,N,ADCHL,0)
0574 C
0575 C SUMPR = 0.0
0576 C DO 230 K = 1,N
0577 C IBUFF(K) = IAND(IBUFF(K),MASK)
0578 C SAMP(K) = FLOAT(IBUFF(K))/ 32768.0
0579 C SUMPR = SUMPR + SAMP(K)
0580 C 230 CONTINUE
0581 C
0582 C CALL WKRMS(N,SAMP,SUMPR,MAX,MIN,RMS)
0583 C ARRAYA(1,J+1) = SUMPR / FLOAT(N)
0584 C ARRAYA(2,J+1) = RMS
0585 C ARRAYA(3,J+1) = MAX
0586 C ARRAYA(4,J+1) = MIN
0587 C 250 CONTINUE
0588 C RETURN
0589 C ----- END SUBROUTINE WKPAC *****
0590 C END
0591 C ***** C

```


A.6 SUBROUTINE--WKRMS

A.6.1 Description of WKRMS

This subroutine takes the array of sampled pressures from WKPAC and calculates the maximum, minimum, and root-mean-square (RMS) values of the sample set. The RMS is used to examine the stability of the pressure measurements at each point. Without the RMS value, a spike in the data would cause a large difference between the maximum or minimum and the average value. An observer would be unable to tell whether the entire data set fluctuated greatly, or just one sample. A low RMS value would indicate that the data is stable, while a large RMS value would indicate that the flow was fluctuating at that point.

The subroutine determines maximum and minimum by logical comparison. The root-mean-square value is determined from the following equation. [Ref. 24]

$$\sigma = \sqrt{\frac{\sum (P - P_{av})^2}{N}} \quad (A6-1)$$

where P is a sampled pressure, P_{av} is the average pressure of the sample set (SUMPR/N), and N is the number of samples taken.

The three parameters are returned to WKPAC for storage in ARRAYA.

A.6.2 Nomenclature & Listing for Subroutine WKRMS

FN	real	Floating point value of N
MAX	real	Maximum value of sample set
MIN	real	Minimum value of sample set
N	integer	Number of Kulite samples taken each of the 256 blade-to- blade locations
RMS	real	Root-mean-square value of samples
SAMP(99)	real	Floating point array of samples
SUM	real	Sum of the mean-squares
SUMPR	real	Sum of samples

&WKAQN T=00004 IS ON CR00028 USING 00126 BLKS R=0000

```

0591 C ***** C
0592 SUBROUTINE WKRMS(N,SAMP,SUMPR,MAX,MIN,RMS)
0593 C * USED WITH &WKAQN TO CALCULATE MAXIMUM, MINIMUM, AND RMS * C
0594 C * OF WALL-KULITE PRESSURE MEASUREMENTS FOR THE TRANSONIC * C
0595 C * COMPRESSOR. FOR MORE COMPLETE DESCRIPTION, SEE CORNELL, * C
0596 C * NPS THESIS, 1983. * C
0597 C * VER 2.0 JUL 1983 DWC * C
0598 C ***** C
0599 C
0600 C DIMENSIONS
0601 REAL MAX,MIN,RMS,SUM,SAMP(99),SUMPR,FN
0602 INTEGER N
0603 C INITIAL VALUES
0604 FN = FLOAT (N)
0605 MAX = SAMP(1)
0606 MIN = SAMP(1)
0607 SUM = (SAMP(1) - SUMPR/FN)**2
0608 C CALCULATIONS
0609 DO 10 I = 2,N
0610 IF ( SAMP(I) .GT. MAX ) MAX = SAMP(I)
0611 IF ( SAMP(I) .LT. MIN ) MIN = SAMP(I)
0612 SUM = SUM + (SAMP(I) - SUMPR/FN)**2
0613 10 CONTINUE
0614 RMS = SQRT(SUM/FN)
0615 RETURN
0616 C ----- END SUBR WKRMS ----- C
0617 END
0618 C ***** C

```


A.7 SUBROUTINE--XTREM

A.7.1 Description of XTREM

This subroutine is called by the main program to calculate parameters of the unsteady pressure acquisition to be output to the printer. It determines the maximum, minimum, and average values of the already averaged data for each of the two blade passages covered. The "1" values, corresponding to the first blade passage of the data set, are calculated from ARRAYA columns 1 to 128. The "2" values, corresponding to the second blade passage, use columns 129 to 256.

After the sum and extreme values are calculated, the routine converts the pressure values to units of inches of water using the following equation.

$$P(\text{in. H}_2\text{O}) = P(\text{volts}) * 100000.0 / \text{GAIN} \quad (\text{A7-1})$$

where 100000.0 is the scaling factor and GAIN is the voltage gain of the Datel amplifiers. (Currently set at 40).

A listing of the remaining functions used in the program is also provided.

A.7.2 Nomenclature & Listing for Subroutine XTREM

AVG1,AVG2	real	Average pressure across 1st, 2nd blade passage
GAIN	real	Voltage gain of Datel ampli- fiers
MAX1,MAX2	real	Maximum pressure across 1st, 2nd blade passage.
MIN1,MIN2	real	Minimum pressure across 1st, 2nd blade passage
PLT(256)	real	Array of averaged Kulite data
SUM1,SUM2 .	real	Sum of averaged pressure across one blade passage

&WKAQN T=00004 IS ON CR00028 USING 00126 BLKS R=0000

```

0618 C *****
0619 SUBROUTINE XTREM (PLT,MAX1,MAX2,MIN1,MIN2,AVG1,AVG2,GAIN)
0620 C * USED WITH WKPAC AS ROUGH INDICATION WHETHER BOTH WAVEFORMS * C
0621 C * ARE ACQUIRED CORRECTLY. FINDS MAXIMUM,MINIMUM, AND AVERAGE * C
0622 C * VALUES OF WAVEFORMS, AND RETURNS IN INCHES OF WATER. * C
0623 C * MARCH 1983 DWG * C
0624 C *****
0625 C
0626 C DIMENSIONS
0627 REAL PLT(256),MAX1,MIN1,MAX2,MIN2,SUM1,SUM2,AVG1,AVG2
0628 C INITIAL VALUES
0629 MAX1 = -2000000.0
0630 MAX2 = MAX1
0631 MIN1 = - MAX1
0632 MIN2 = - MAX1
0633 SUM1 = 0.0
0634 SUM2 = SUM1
0635 C CALCULATIONS
0636 DO 10 I = 1,128
0637 IF (PLT(I) .GT. MAX1) MAX1 = PLT(I)
0638 IF (PLT(I) .LT. MIN1) MIN1 = PLT(I)
0639 SUM1 = SUM1 + PLT(I)
0640 10 CONTINUE
0641 MAX1 = MAX1 * 10000. / GAIN
0642 MIN1 = MIN1 * 10000. / GAIN
0643 C
0644 DO 20 J = 129,256
0645 IF (PLT(J) .GT. MAX2) MAX2 = PLT(J)
0646 IF (PLT(J) .LT. MIN2) MIN2 = PLT(J)
0647 SUM2 = SUM2 + PLT(J)
0648 20 CONTINUE
0649 MAX2 = MAX2 * 10000.0 / GAIN
0650 MIN2 = MIN2 * 10000.0 / GAIN
0651 AVG1 = SUM1 / 128.0 * 10000.0 / GAIN
0652 AVG2 = SUM2 / 128.0 * 10000.0 / GAIN
0653 RETURN
0654 END
0655 C *****

```


ΔWKAGN T=00004 IS ON CR00028 USING 00126 BLKS R=0000

```

0655 C ***** C
0656 REAL FUNCTION ACQN(IVALVE,IADES,IW)
0657 C * THIS PROGRAM POSITIONS S/V "IVALVE" TO PORT * C
0658 C * "IADES" AND DEFINES ACQN=DVM VOLTAGE. A DELAY * C
0659 C * OF (IW*10) MILLISECONDS OCCURS BETWEEN PORT * C
0660 C * SELECTION AND VOLTAGE MEASUREMENT. * C
0661 C ***** C
0662 C
0663 IF(IVALVE.LT.1 .OR. IVALVE.GT.5) GO TO 900
0664 IF(IADES .LT.1 .OR. IADES .GT.48)GO TO 900
0665 ISTEP=1
0666 IF(IVALVE.EQ.2 .OR. IVALVE.EQ.3) ISTEP=2
0667 10 IAPR = IPORT(IVALVE)
0668 IDEL = IADES-IAPR
0669 IF(IDEL) 100,200,300
0670 C --- HOME ---
0671 100 ICHAN = ICON(IVALVE,4)
0672 K=2
0673 GO TO 400
0674 C --- READ ---
0675 200 ICHAN = ICON(IVALVE,9)
0676 K=3
0677 GO TO 400
0678 C --- ADVANCE ---
0679 300 ICHAN = ICON(IVALVE,-1)
0680 K=1
0681 C --- CONTROL ---
0682 400 CALL CNTL(ICCHAN,IDEL,ISTEP,K)
0683 IF(K.NE.3) GO TO 10
0684 C --- PAUSE & READ ---
0685 CALL WAIT(IW)
0686 WRITE(10,59)
0687 59 FORMAT("T3")
0688 READ(10,*)ACQN
0689 WRITE(8,60)
0690 60 FORMAT("C")
0691 RETURN
0692 C --- PRINT ERROR MESSAGE ---
0693 900 WRITE(1,910)IVALVE,IADES
0694 910 FORMAT(SX,"BAD INPUT TO ACQN: IVALVE =",I4," IADES =",I4)
0695 STOP 1
0696 END
0697 C ***** C
0698 SUBROUTINE CNTL(ICCHAN,IDEL,ISTEP,K)
0699 C * THIS PROGRAM CLOSSES SCANNER CHANNEL "ICCHAN" * C
0700 C * "IDEL" TIMES IN STEPS OF "ISTEP" BASED UPON * C
0701 C * PROGRAM OPTIONS SPECIFIED BY "K". (ICCHAN MUST * C
0702 C * BE AN ASCII-CONVERTED INTEGER.) * C
0703 C ***** C
0704 GO TO(100,200,300),K
0705 C
0706 100 DO 10 I=1,IDEL,ISTEP
0707 WRITE(8,60)ICCHAN
0708 CALL WAIT(1)
0709 WRITE(8,62)
0710 CALL WAIT(15)
0711 10 CONTINUE
0712 RETURN

```



```

0713 C
0714 200 WRITE(8,60) ICHAN
0715 CALL WAIT(1)
0716 WRITE(8,62)
0717 CALL WAIT(400)
0718 RETURN
0719 C
0720 300 WRITE(8,60) ICHAN
0721 RETURN
0722 C
0723 60 FORMAT(A2)
0724 62 FORMAT("C")
0725 END
0726 C ***** C
0727 INTEGER FUNCTION ICON(I,N)
0728 C ***** C
0729 IC=I+N
0730 IF(IC.LT.10) GO TO 100
0731 CALL CODE
0732 WRITE(ICON,60) IC
0733 60 FORMAT(I2)
0734 RETURN
0735 100 ICON=IC+30060B
0736 RETURN
0737 END
0738 C ***** C
0739 INTEGER FUNCTION IPORT (IVALVE)
0740 C ***** C
0741 LU = 14 + 2100B
0742 CALL EXEC(2,LU,IVALVE*256,-1)
0743 CALL EXEC(1,LU,IP,-1)
0744 IP=IP/256
0745 MSD = IAND(IP/16,7B)
0746 LSD = IAND(IP,17B)
0747 IPORT = 10*MSD + LSD
0748 CALL ABRT(7,1)
0749 RETURN
0750 END
0751 C ***** C
0752 REAL FUNCTION SCANR(LU,ICHAN,K)
0753 C * THIS PROGRAM CLOSES RELAY 'ICHAN' ON SCANNER 'LU' * C
0754 C * AND READS THE INSTRUMENT INDICATED BY 'K'. (FROM TXCOU) * C
0755 C * **** NOTE: INSTRUMENT FUNCTION CODES MUST BE SET TO * C
0756 C * EXPECT REMOTE TRIGGERING PRIOR TO ENTERING THIS PROGRAM * C
0757 C ***** C
0758 WRITE(8,801)
0759 WRITE(15,1501)
0760 IC=ICON(ICHAN,0)
0761 WRITE(LU,101) IC
0762 GO TO(100,200) K
0763 100 CALL TRIGR (10)
0764 READ (10, *) DUM
0765 CALL TRIGR (10)
0766 READ (10, *) SCANR
0767 GO TO 300
0768 200 WRITE(12,1201)
0769 READ(12, *) SCANR
0770 300 WRITE(LU,801)
0771 101 FORMAT (A2)
0772 801 FORMAT ("C")

```



```

0773 1001 FORMAT ("T3T3")
0774 1201 FORMAT ("T")
0775 1501 FORMAT ("C")
0776      RETURN
0777 60   FORMAT(A2)
0778 61   FORMAT("T3")
0779 62   FORMAT("C")
0780 63   FORMAT("T")
0781      END
0782 C ***** C
0783      SUBROUTINE WAIT (N)
0784 C *          THIS PROGRAM USES THE HP-21MX SYSTEM CLOCK TO          * C
0785 C *          PRODUCE A DELAY OF (N*10) - MILLISECONDS.          * C
0786 C ***** C
0787      DIMENSION IT(5)
0788      CALL EXEC (11,IT,IY)
0789      NM=IT(3)
0790      ITF=IT(1) + 100*IT(2) + N
0791 10   IF(ITF.LE.5999) GO TO 20
0792      NM=NM + 1
0793      ITF=ITF - 6000
0794      GO TO 10
0795 20   CALL EXEC (11,IT,IY)
0796      INOW=IT(1) + 100*IT(2)
0797      IF(ITF-INOW)30,30,20
0798 30   IF(NM-IT(3))99,99,20
0799 99   RETURN
0800 C ***** END OF FILE
0801      END

```


A.8 SON PROGRAM--WKPLT

A.8.1 Description of WKPLT

This program, used almost without change from the TPL program library, is called by the main program to plot the Kulite waveforms during the acquisition of unsteady data. The user is able to then evaluate whether the data is acceptable to store or whether the data should be retaken. The program offers the user the choice of the output device so that the waveform may be observed on the terminal and, if desired, it can be output to the plotter for a hard copy. The library subroutines and their parameters are described in the Hewlett-Packard Graphic Reference Manual. [Ref. 25]

2.8.2

* &WKPLT T=00004 IS ON CR00028 USING 00018 BLKS R=0000

```

0001  FTN4,L
0002      PROGRAM WKPLT
0003  C*****
0004  C
0005  C      PROGRAM FOR PLOTTING THE AVERAGE KULITE WAVEFORMS
0006  C
0007  C*****
0008  C
0009  C      INITIALIZE VARIABLES AND RETRIEVE PASSED PARAMETERS
0010  C
0011      REAL DA(256),D(2,256),AR,VX1,VX2,VY1,VY2,RMAX,RMIN,DIV,AUG,PY
0012      *,      RKU(12)
0013      INTEGER J,ICOUNT,ID,LU,ICON,ICODE,IL,JUMP
0014      DIMENSION IGCB(192),IP(5)
0015      DATA D/512*0.0/
0016      DATA RKU/6.0,7.0,7.5,8.0,8.5,9.0,9.5,10.0,10.5,11.0,12.0,13.0/
0017      CALL RMPAR (IP)
0018      LU = IP(2)
0019      ICOUNT = IP(3)
0020      ICHAN = IP(4)
0021      DIV = 1.0
0022      AVG = 0.0
0023      ID = 1
0024      IF (LU .EQ. 13) ID = 2
0025      ICODE = 14 + 1000008
0026      IL = 512
0027      JUMP = 1
0028      CALL EXEC (ICODE,1,DA,IL)
0029      GO TO 400
0030      10 JUMP = JUMP + 1
0031      RMAX = DA(1)
0032      RMIN = RMAX
0033      DO 15 J = 2,256
0034      IF (DA(J) .GT. RMAX) RMAX = DA(J)
0035      15 IF (DA(J) .LT. RMIN) RMIN = DA(J)
0036      IF (LU .EQ. 1 .OR. ICOUNT .GT. 1) GO TO 20
0037  C
0038  C      INITIALIZE THE GRAPHICS TASK
0039  C
0040      WRITE (1,500)
0041      500 FORMAT ("POSITION THE PAPER ON THE PLOTTER"
0042      *,/,      "WHEN THIS IS DONE,      ENTER 1"
0043      *,/,      "IF YOU WISH TO STOP,      ENTER 0")
0044      READ (1,*) ICON
0045      IF (ICON .EQ. 0) GO TO 999
0046      20 CALL PLOTR (IGCB,ID,1,LU)
0047  C
0048  C      DEFINE THE VIEWING SURFACES
0049  C
0050      IF (LU .EQ. 1) AR = 1.5
0051      IF (LU .EQ. 13) AR = 1.35
0052      VX1 = 20.
0053      VX2 = 100. * AR - 20.
0054      IF (AR .LT. 1) VX2 = 80.
0055      VY1 = 20.
0056      VY2 = 80.
0057      IF (AR .LT. 1) VY2 = 100. / AR - 20.
0058      CALL SETAR (IGCB,AR)

```



```

0059      CALL VIEWP (IGCB,UX1,UX2,UY1,UY2)
0060      CALL WINDOW (IGCB,0.,256.,-1.,.25)
0061  C
0062  C  NORMALIZE THE DATA IF NECESSARY AND PLACE IN THE PLOT ARRAY
0063  C
0064      IF (RMAX .LE. 1.0 .AND. RMIN .GE. (-1.0)) GO TO 30
0065      WRITE (1,510) RMAX,RMIN
0066  510 FORMAT ("ONE OF THE FOLLOWING OUT OF RANGE:"
0067      *,/,      "RMAX = ",F8.4,"      RMIN = ",F8.4
0068      *,/,      "DIVIDING DATA BY LARGEST ABS VALUE OF THE TWO!")
0069      DIV = ABS (RMAX)
0070      IF (ABS (RMIN) .GT. DIV) DIV = ABS (RMIN)
0071      30 DO 40 J = 1,256
0072          AVG = AVG + DA(J)
0073          D(1,J) = FLOAT (J)
0074      40 D(2,J) = DA(J) / DIV
0075          AVG = AVG / 256.0
0076  C
0077  C  DRAW THE AXES
0078  C
0079      CALL PEN (IGCB,ICOUNT)
0080      IF (LU .EQ. 1) GO TO 45
0081      IF (ICOUNT .NE. 1) GO TO 50
0082      WRITE (1,520)
0083  520 FORMAT ("DO YOU NEED A NEW FRAME?  YES = 1"
0084      *,/,      "                      NO  = 0")
0085      READ (1,*) ICON
0086      IF (ICON .EQ. 0) GO TO 50
0087      45 CALL FXD (IGCB,2)
0088      IF (LU .EQ. 1) CALL LGRID (IGCB,-32.,.25,0.,0.0,2.,1.)
0089      IF (LU .EQ. 13) CALL LGRID (IGCB,-32.,.25,0.0,-.25,2.0,2.,1.)
0090  C
0091  C  PLOT THE DATA
0092  C
0093      50 CALL MOVE (IGCB,D(1,1),D(2,1))
0094      DO 60 J = 1,256
0095      60 CALL PLOT (IGCB,D(1,J),D(2,J),1)
0096      CALL PENUP (IGCB)
0097  C
0098  C  WRITE THE MAX, AVERAGE, AND MIN VALUES ON THE PLOT
0099  C
0100      PY = (-0.62) - 0.08 * ICOUNT
0101      CALL MOVE (IGCB,5.,PY)
0102      CALL LABEL (IGCB)
0103      WRITE (LU,530) RKU(ICHAN),RMAX,AVG,RMIN
0104  530 FORMAT ("KU =",F5.1,"  MAX =",F6.3,"  AVG =",F6.3,"  MIN =",F6.3)
0105  C
0106  C  TERMINATE THE GRAPHICS TASK AND RETURN DATA
0107  C
0108      CALL PEN (IGCB,0)
0109      100 WRITE (1,540)
0110  540 FORMAT ("EXAMINE THE DATA -- WHEN READY TO CONTINUE,  ENTER 1")
0111      READ (1,*) ICON
0112      CALL GCLR (IGCB)
0113      CALL PLOTR (IGCB,ID,0)
0114      CALL EXEC (ICODE,2,DA,IL)
0115      GO TO 400
0116      70 IP(2) = LU
0117      IP(3) = ICOUNT
0118      CALL PRN (IP)

```



```

0119      GO TO 80
0120 C
0121 C  ERROR PROCESSING SECTION
0122 C
0123      400 CALL ABREG (IA,IB)
0124      WRITE (1,600) IA,IB
0125      600 FORMAT ("ERROR IF &RAWPL DURING DATA FILE RETRIEVAL/STORAGE:"
0126      *,/,      "A-REGISTER = ",I6," (ASCII CODE FOR THE ERROR TYPE)"
0127      *,/,      "B-REGISTER = ",I6," (ASCII CODE FOR THE ERROR NUMBER)"
0128      *,/,      "REFER TO CHAPTER 2 OF THE 'RTE-IVB PROGRAMMERS "
0129      *,      "REFERENCE MANUAL' FOR",/,,"      MORE INFORMATION.")
0130      IF (JUMP .EQ. 1) GO TO 10
0131      GO TO 70
0132      80 CALL EXEC (6)
0133      999 STOP
0134      END

```


APPENDIX B

REDUCTION SOFTWARE

B.1.1 INTRODUCTION

The raw case-wall data acquired by the acquisition program WKAQN is stored in files on disk of the HP-21MX computer. That data is output and transferred to the IBM 3033 computer for reduction. The FORTRAN program WKCONCP is used to convert the recorded voltages to pressure coefficients, even the spacing of the array by interpolation, and store the newly generated array on the IBM disk for use in the plotting program. Program WKCONCP is described, with flowchart and listing, in Section B.2.

The FORTRAN program WKCONPLT is used to read the coefficient file and generate the graphics vectors to produce contour maps. The output of WKCONPLT can be directed to any of several devices. (The maps reproduced in the present document were generated on a Versatec plotter.) Program WKCONPLT is described, with flowchart and listing, in Section B.3.

B.1.2 Nomenclature for Reduction Programs

A,B,C,	real	Coefficients for Ps9 equation
A0	real	Intercept of P-e curve
A1	real	Slope of P-e curve
As9	real	Speed of sound at S9 (m/sec)
e	real	Kulite voltage (P-PKR)
GAMMA	real	Ratio of specific heats, 1.405
K0	real	Intercept of e-PKR curve
K1	real	Slope of e-PKR curve
Ms9	real	Mach number at S9
P	real	Unsteady absolute static pressure in compressor
PATM	real	Atmospheric pressure
PE	real	Unsteady pressures after being Smoothed and evened
PKR	real	Kulite reference pressure
PNR	real	Pneumatic reference pressure
Ps	real	Pneumatic pressure
Ps9	real	Freestream reference static pressure
Qs9	real	Freestream reference dynamic pressure
R	real	Gas constant, for air $287 \frac{\text{N-M}}{\text{Kg}^\circ\text{K}}$
FO	real	Radius of flow meter throat (meters)
RPM	integer	Shaft anular velocity (RPM)
t	real	Temperature signal from thermocouple
TT	real	Total temperature ($^\circ\text{K}$)
U	real	Rotor speed (m/sec)
WS	real	Referred flow rate

B.2 DATA REDUCTION PROGRAM--WKCONCP

B.2.1 Description of Program WKCONCP

The pressure data were reduced using the FORTRAN program WKCONCP which accesses the data stored from the acquisition, converts the Kulite voltages to pressure coefficients, evens the spacing of the array, and smooths the data. A flowchart for the program WKCONCP is shown in figure B-1.

After the raw data is read from the disk, the voltage is converted to pressure in inches of water using the relationship:

$$P = A0 + A1 (e * 10000./GAIN) + PKR \quad (B2-1)$$

where "GAIN" is the voltage gain of the Datel amplifier between the transducer and the A/D.

The data are then spaced evenly by a linear interpolation scheme. Figure 7 of the main report shows how the Kulite transducers, labeled K6 to K13, are spaced at different distances apart. Since the contour plotting routine assumes equal spacing, it can not be applied to data in the form it is acquired. The data array is therefore expanded to 16 x 256 by a linear interpolation between the Kulite locations, giving data at E1 to E16 from data at K6 to K13. (Figure 7)

The data in the present report were smoothed in the blade-to-blade (circumferential) direction to remove spikes. A cubic spline interpolation prediction method was used from the IMSL Library of FORTRAN subroutines. The

WKCONCP

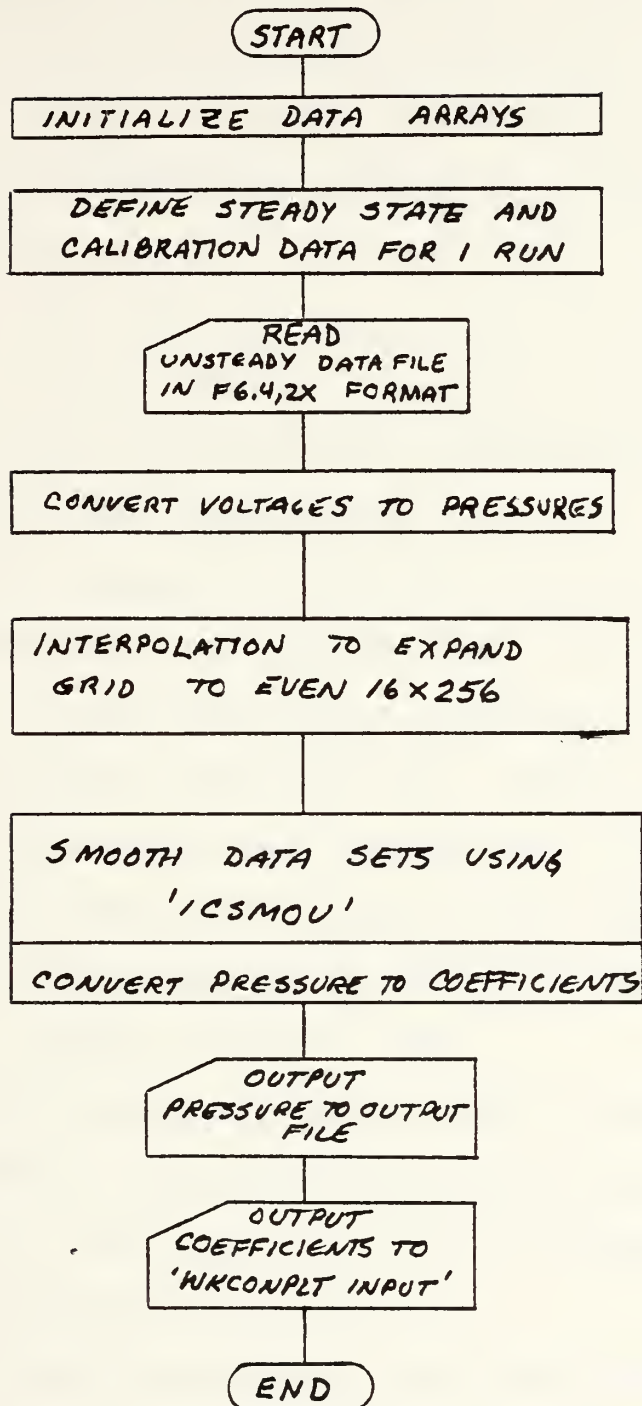


Figure B.1 Flowchart for WKCONCP

subroutine "ICSMOU" uses slopes calculated from previous points to predict the next data point. If the data point is out of the criterion specified, the point is thrown out and a predicted point is inserted in the data.

The program then calculates the pressure coefficient defined as:

$$C_p = P_E - P_{s9} / Q_{s9} \quad (B2-2)$$

where static pressure, P_E , is the unsteady pressure data read during paced acquisition that has been smoothed and expanded to an evenly spaced array.

The "freestream reference pressure, P_{s9} , is a steady pneumatic inferred from measurements at wall pressure taps upstream of the rotor and extrapolated to the rotor entrance by parabolic curve fitting. Static taps 1 through 6 are read during the on-line calibration. Static pressures recorded by the Scanivalve (pneumatic) are converted to pressures in units of inches of water using the relationship:

$$P_s = (P_N - TARE) * 100000. + PNR \quad (B2-3)$$

where P_N is the pneumatic pressure read via the Scanivalve, PNR is a pneumatic reference pressure applied to the Scanivalve, and $TARE$ is the Scanivalve transducer output with zero differential pressure.

Pneumatic pressures were used from three sets of data obtained at an open throttle. The ratio of P/P_t was plotted against axial distance for each set of data. A parabolic

curve fitting was used to acquire a second order equation in terms of x, the axial distance giving

$$P/P_t = -.0011X^2 + .0016 \cdot X + .9525 \quad (B2-4)$$

This was repeated for the other two sets of data. Then, the coefficients of each term were plotted versus referred flow rate. Each coefficient curve was approximated resulting in second order equations for the coefficients as a function of referred flow rate. The equations obtained were:

$$A = -.0011 WS^2 + .0149 \cdot WS + .9174 \quad (B2-5a)$$

$$B = .0006 \cdot WS - .0042 \quad (B2-5b)$$

and

$$C = -.0003 \cdot WS + .0018 \quad (B2-5c)$$

Knowing the location at the inlet to the rotor, (x=5.375), the ratio P_{s9}/P_t becomes:

$$P_{s9}/P_t = A = 5.375 \cdot B + 28.891 \cdot C \quad (B2-6)$$

Substituting equations B2-5 into equation B2-6, the reference pressure is written as a function of referred flow rate alone, thus

$$P_{s9} = 0.9468 + .00946 \cdot WS - .0011 \cdot WS^2 \quad (B2-7)$$

Dynamic pressure is obtained from the following relationship:

$$Q_{s9} = 1/2 \cdot \gamma \cdot P_{s9} (M_{s9}^2 + U^2/A_{s9}^2) \quad (B2-8)$$

The reference Mach number is calculated from the Perfect Gas relationship:

$$M_{s9} = \left(\frac{2}{\gamma - 1} \left((P_t/P_{s9})^{\frac{\gamma - 1}{\gamma}} - 1 \right) \right)^{1/2} \quad (B2-9)$$

The stagnation pressure, P_t , is read at the compressor inlet.

The rotor tip speed, U , is calculated from the shaft speed and the radius of the case-wall (5.5 inches).

$$\begin{aligned} U &= \text{RPM} * 2\pi(5.5)/60/12 * .3048 & (\text{B2-10}) \\ &= \text{RPM} * (0.014629) \text{ m/sec} \end{aligned}$$

The speed of sound, A_{s9} , is calculated from the Perfect Gas relationship:

$$A_{s9} = (\gamma R \cdot T_t \cdot (1 + \frac{\gamma-1}{2} M_{s9}^2)^{-1})^{1/2} \quad (\text{B2-11})$$

Total temperature is obtained from the millivolt output, t , of a J-type thermocouple probe in the inlet and converting the value to degrees Kelvin using,

$$TT = (t*1000.*34.7279+.6149)*5/9+273.15 \quad (\text{B2-12})$$

With all of the terms defined, the pressure coefficient can be written:

$$C_p = (A_0 + A_1 * (e * 10000. / \text{GAIN}) + \text{PKR} - P_{s9}) / Q_{s9} \quad (\text{B2-13})$$

The array of coefficients calculated using Equation B2-3 is stored in a file to be used in the contour program.

B.2.2

FILE: WKCONCF FORTRAN A NAVAL POSTGRADUATE SCHOOL

```

C *****
C PROGRAM WKCONCF IS USED TO PLOT CONTOUR MAPS OF DATA ACQUIRED
C FROM THE TRANSONIC COMPRESSOR AT THE TURBOPROPULSION LAB AT
C THE NAVAL POSTGRADUATE SCHOOL. REQUIRED INPUT IS 12 X 256
C ARRAY OF WALL PRESSURE DATA IN 8 X 384 STORAGE FORMAT. THUS
C EACH ROW IS STORED 8 X 32. OUTPUT IS STORED IN 16 X 256
C ARRAY AS A 8 X 512. I/O FORMAT 8(F6.4,2X)
C VER. 3.0 1 SEPTEMBER 1983 DMC
C *****
C ----- '100' ----- DIMENSIONS AND INITIAL VALUES -----
C REAL CA(12,256),P(12,256),FE(16,256),CP(16,256)
C REAL AC,A1,A01(12),A02(12),A11(12),A12(12)
C REAL X(256),Y(256),WK2(500),WK1(20),X1(16),Y1(16),DIS,SC
C REAL GAIN,GAMMA,R,PATM,TAR1,PT,TT,PS,PR,RPM,MFR,U,M2,C,A2,M
C INTEGER BF,N,IM,IN,MAXIT
C DO 110 I=1,12
C   Y1(I) = 0.0
C   Y1(I+4) = 0.0
C   DO 105 J=1,256
C     CA(I,J) = 0.0
C     F(I,J) = 0.0
C     Y(J) = 0.0
C   105 CONTINUE
C 110 CONTINUE
C   DO 150 J=1,256
C     FE(I,J) = 0.0
C     CP(J,I) = 0.0
C   140 CONTINUE
C 150 CONTINUE
C DATA GAMMA/1.402/,GAIN/40./,R/287.06/
C INPUT VALUES FOR EACH RUN IN THE
C NEXT LINES
C DATA A11/1.011,1.012,0.983,1.005,1.010,0.993,1.005,0.997,C.993,
C 1 1.009,0.711,1.001/
C DATA A12/1.005,1.001,0.977,1.000,1.012,0.987,1.003,1.000,1.015,
C 1 1.005,1.007,1.019/
C DATA A01/49.312,52.452,55.47C,55.745,52.892,54.837,52.205,34.782,
C 1 19.630,0.5258, .571,-13.61/
C DATA AC2/49.099,52.378,55.885,55.799,52.914,54.613,52.428,34.873,
C 1 18.939,5.231,-10.23,-14.60/
C PATM = 404.79
C TAR1 = ( -.000006 +.000005 ) / 2.0 * 100000.0
C PT = ( -.00014 + -.00015 ) * 100000.0 / 2.0 - TAR1 + PATM
C TT = ( -.00100 + .00095 ) / 2.0 * 1000. * 34.7279 + C.6149
C TT = TT * 5./9. + 273.15
C PS = -72.72+ PATM
C FLOW INPUTS
C PR = 1.235
C RPM = 21420
C MFR = 14.584
C BP = 4
C N = 20
C ----- '200' ----- FLOW CALCULATIONS -----
C U = 0.014629 * RPM
C M2 = 2.0/(GAMMA-1.0) * ( (PT/PS)**((GAMMA-1.0)/GAMMA) - 1.0)
C A2 = GAMMA * R * TT / (1.0 + (GAMMA-1.0)/2.0 * M2)
C Q = GAMMA/2.0 * PS * ( M2 + (U*U)/A2 )
C Q = 132.
C M = SQRT(M2)
C ----- '300' ----- READ DATA FILES -----
C DO 320 I = 1,12
C IF ( I.LT. 10 ) WRITE(4,910) I
C IF ( I.GT. 9 ) WRITE(4,911) I
C DO 310 J = 1,249,8
C J1 = J - 1
C FEAL(3,920) (DA(I,J1+J2),J2=1,8)
C WRITE(4,930) (DA(I,J1+J2),J2=1,8)
C 310 CONTINUE
C 320 CONTINUE
C ----- '400' ----- CHANGING VOLTS TO PRESSURE -----

```



```

      DO 42C I = 1,12
      IF ( I .LT. 10 ) WRITE(4,940) I
      IF ( I .GT. 9 ) WRITE(4,941) I
      A0 = ( A01(I) + A02(I) ) / 2.0
      A1 = ( A11(I) + A12(I) ) / 2.0
      DO 410 J = 1,256
      P(I,J) = (CA(I,J) * 100CO. / GAIN)* A1 + A0 + PATM
410    CCNTINLE
      DO 415 J = 1,249,8
      J2 = J-1
      WRITE(4,970) (P(I,J1+J2),J1=1,8)
415    CCNTINLE
420  CONTINUE
C----- '500' ----- EVENING DISTRIBUTION OF COLUMNS
C----- EQUIVALENCE OF INTERIOR ROWS
      DO 52C J = 1,256
      DC 510 I = 3,10
      PE(I+2,J) = P(I,J)
510    CONTINUE
      PE(14,J) = P(11,J)
      PE(13,J) = ( P(10,J) + P(11,J) ) / 2.
      CREATE 13E FROM 10 + 11
      PE(15,J) = (.19/.5)*( P(12,J) - P(11,J) ) + P(11,J)
      CREATE 15E + 16E FROM 11 + 12
      PE(16,J) = (.38/.5)*( P(12,J) - P(11,J) ) + P(11,J)
      CREATE 4E FROM 2 + 3
      PE(4,J) = (.12/.31)*( P(3,J) - P(2,J) ) + P(2,J)
      CREATE 1E,2E + 3E FROM 1 + 2
      PE(1,J) = (.05/.5)*( P(2,J) - P(1,J) ) + P(1,J)
      PE(2,J) = (.24/.5)*( P(2,J) - P(1,J) ) + P(1,J)
      PE(3,J) = (.43/.5)*( P(2,J) - P(1,J) ) + P(1,J)
520  CONTINUE
      DC 54C I = 1,16
      IF ( I .LT. 10 ) WRITE(4,95C) I
      IF ( I .GT. 9 ) WRITE(4,951) I
      DO 515 J = 1,249,8
      J2 = J-1
      WRITE(4,970) (PE(I,J1+J2),J1=1,8)
515    CCNTINLE
540  CONTINUE
C----- '600' ----- SMOOTHING DATA -----
C----- CALCULATING CP'S AND ECHOPRINT
      DO 65C I = 1,16
      DC 630 J = 1,256
      X(J) = J
      Y(J) = PE(I,J)
630    CCNTINLE
      DIS = 1.0
      SC = .C2*3.84*(.43/255)
      MAXIT = 40
      CALL ICSMOU(X,Y,256,DIS,SC,MAXIT,WK2,IER)
      DO 640 J = 1,256
      CP(I,J) = ( Y(J) - PS ) / Q
640    CCNTINLE
650  CONTINUE
      DO 68C I = 1,16
      IF ( I .LT. 10 ) WRITE(4,96C) I
      IF ( I .GT. 9 ) WRITE(4,961) I
      DC 660 J = 1,249,8
      J2 = J-1
      WRITE(4,970) (CP(I,J1+J2),J1=1,8)
660  CONTINUE
680  CONTINUE
C----- '700' ----- WRITE INTO DATA FILES -----
      DO 74C I = 1,16
      DC 720 J = 1,249,8
      J2 = J-1
      WRITE(5,920) (CP(I,J1+J2),J1=1,8)
720  CONTINUE
740  CONTINUE
      STOP

```



```

C ----- '900' ----- FORMATS -----
C910 FORMAT(1H1,/,/,5X,'AVERAGE UNSTEADY WALL PRESSURE DATA -- FILE - ',
C      1,/,/545C',11,/)
C911 FORMAT(1H1,/,/,5X,'AVERAGE UNSTEADY WALL PRESSURE DATA -- FILE - ',
C      1,/,/545C',12,/)
C920 FORMAT(8(F6.4,2X))
C930 FORMAT(5X,8(F6.4,2X),/)
C940 FORMAT(1,/,/,5X,'ARRAY OF PRESSURES -- FILE - ',
C      1,/,/545C',11,/)
C941 FORMAT(1,/,/,5X,'ARRAY OF PRESSURES -- FILE - ',
C      1,/,/545C',12,/)
C950 FORMAT(1,/,/,5X,'ARRAY OF PRESSURES EVENED -- FILE - ',
C      1,/,/545C',11,/)
C951 FORMAT(1,/,/,5X,'ARRAY OF PRESSURES EVENED -- FILE - ',
C      1,/,/545C',12,/)
C960 FORMAT(1,/,/,5X,'ARRAY OF PRESSURE COEFFICIENTS -- FILE - ',
C      1,/,/545C',11,/)
C961 FORMAT(1,/,/,5X,'ARRAY OF PRESSURE COEFFICIENTS -- FILE - ',
C      1,/,/545C',12,/)
C970 FORMAT(5X,8(F8.2),/)
      END

```

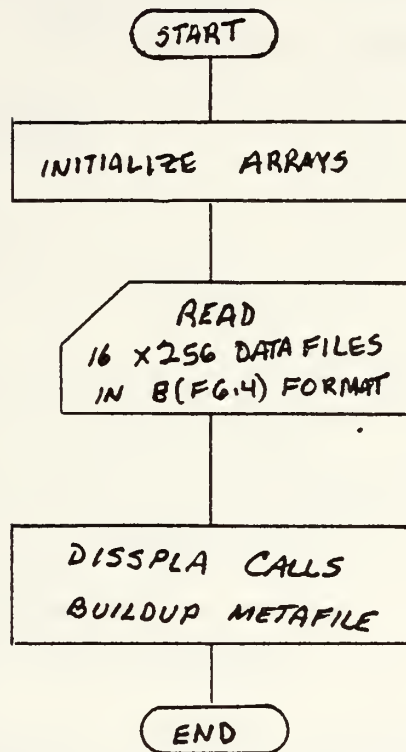

B.3 CONTOUR PROGRAM--WKCONPLT

B.3.1 Description of WKCONPLT

The contour mapping is accomplished using the FORTRAN program WKCONPLT which uses the data stored from the reduction program WKCONCP and generates plot vectors to be output on a selection of devices. A flowchart is shown in Figure B-2.

The program reads the coefficient data from the disk and then calls a series of subroutines from the DISSPLA graphics library. [Ref. 18] The subroutines create a meta-file of vectors that are stored on the disk. An executive routine called 'DISSPOP' is used to retrieve the vectors on a device of the users choice.

WKCONPLT



TO PLOT, ENTER "DISSPOP"

Figure B.2 Flowchart for WKCONPLT


```

C *****
C *      PROGRAM WKCONPLT -- READS DATA FROM "WKCONPOP INPUT A" AND * C
C *      PLCTS THE CONTCUR USING C1SSPLA SUBROUTINES. * C
C *      (TC REDUCE RAW DATA, SEE PROGRAM CCNTCP) * C
C *      DATAFILE MUST BE STORED IN 8(F6.4,2X) FCRMAT X 512 LINES * C
C *      ( THIS IS EQUIVALENT TC 16 X 256 WHERE EACH TRANSDUCER * C
C *      OUTPUT IS STORED 8 X 32.) * C
C *      VER 1.2 * C
C *      1 SEPTEMBER 1983 * C
C ***** Dwc * C
C ----- '100' ----- DIMENSIONS AND INTIALIZING ---
C      DIMENSION W(16,256)
C      CCMGMA WORK(60000)
C      DATA IM,IN/16,256/
C ----- '200' ----- INITIALIZE PLOT ROUTINE -----
C      CALL CCMPRS
C      CALL FAGE(8.5,11.0)
C ----- '300' ----- READ AND ECHGPRINT DATA FILES --
C      DO 32C I=1,16
C        DO 310 J1=1,245,8
C          J2=J1-1
C          REAC(3,910) (W(I,J+J2),J=1,8)
310      CONTINUE
32C      CONTINUE
C      CALL AREA2D(4.8,6.5)
C      CALL SWISSM
C      CALL SFCCFR(30.,1,.01,1)
C      CALL XNAME('S7' COMPRESSOR AXIS S12 3',100)
C      CALL YNAME('CIRCUMFERENTIALS',100)
C      CALL SWISSB
C      CALL READIN('70% RPM; OPEN THROTTLES',100,1.5,3)
C      CALL SWISSM
C      CALL READIN('COEFFICIENTS-ACT SMOOTHED$',100,1.0,3)
C      CALL READIN('DELTA = 0.08$',100,1.0,3)
C      CALL GRAF(1.,3,16,0.,32,256)
C      CALL FRAME
C      CALL ECCMCN(60000)
C      CALL CCNMAK(W,IM,IN,.08)
C      CALL CCNANG(90.)
C      CALL CCNLI(0,'SOLID','LABEL',2,5)
C      CALL CCNTUR(1,'LABELS','DRAW')
C      CALL ENDPL(0)
C      CALL ECNEPL
C      STCP
C ----- '900' ----- FCRMATS-----
C 910  FORMAT(8(F6.4,2X))
C ----- '1000' ----- END OF FILE -----
C      END

```


APPENDIX C

TRANSONIC CASCADE

C.1 CASCADE BACKGROUND

The cascade wind tunnel which is a seven-tenths scale model of the relative flow at the Transonic Compressor rotor tip was designed by Demo in 1978. [Ref. 2] Due to the limitations of the blowdown air supply available for the cascade, the area of the test section was limited, but contains 5 blade passages. The flow conditions were designed to be Mach - 1.4 instead of the TCR design condition of Mach - 1.5. This compromise allowed a run time of about two to three minutes.

Preliminary blowdown tests were conducted in September 1978 with the blades removed. [Ref. 26] Operation at a stagnation pressure of 50 psia was verified.

Prior to further testing of this facility, a porous wall was designed by Volland to reduce the shock-boundary reflection. (See Ref. 3, Figure 10) Three test programs were conducted by Volland in 1980; (1) Calibration tests, (2) Cascade tests (wall plenum capped and uncapped), and (3) the Wave Cancellation tests. Repeatable data were obtained with the blades installed, however the pressure dropped throughout the test section because the exhaust was open to the atmosphere. The design called for a butterfly valve to create a

controlled back-pressure, but a suitable valve was not available at that time, nor was the test section equipped with the windows necessary for Schlieren observations. These two omissions were addressed in the present work.

C.2 CURRENT MODIFICATIONS

Volland reported uncertain shock patterns inferred from wall pressure measurements in his tests which reemphasized the need for optical viewing of the cascade section. The plexiglass plates designed by Demo were not built. Since optical quality glass would allow better Schlieren photography than would plexiglass, a window was designed for an available piece of optically flat and polished glass. However, due to the complexity and expense of manufacturing the glass window, a plexiglass window was built first. The resulting hardware is shown in Figure C-1. The drawings with specifications are found in Section C.4.

A special throttle valve was designed in 1982. The valve was required to be quick to actuate, sensitively controllable, and allow a negligible pressure drop when fully open. The resulting design is seen in the drawings in Section C.5. The ramp assembly is designed to be actuated by a hydraulic cylinder powered by a hand hydraulic pump. The ramp would be out of the flow path until after start-up, suddenly inserted to a stop, and remain in place for the duration of the test run. The eccentric cylinder on the top

of the throttle allows the operator to fine tune to the flow conditions desired.

C.3 RECOMMENDATIONS FOR THE CASCADE PROJECT

The modifications recommended by Volland are almost completed. The optical window is installed for the Schlieren observations. The throttle valve design is completed and most of the parts are manufactured. Some machining is still required to complete the ducting between the test section and the throttle. In order to test the cascade, the following steps are necessary.

1. Complete the machining of part numbers 5138, 5140, and 5141.
2. Assemble the throttle valve noting that an additional stand will be required to support the weight of the throttle and the duct. The stand will also provide an anchor for the ramp actuating cylinder.
3. A hand-operated hydraulic pump system is available, but needs to be tested for integrity and pressure output. A mounting bracket for the actuating cylinder needs to be designed, built, and installed.
4. It is suggested that a manometer board be used to measure the flow conditions during initial testing to establish the desired flow conditions.
5. A Schlieren system should be set up and tested in the static tunnel.

6. With the plastic duct in place to exit the flow outside of the laboratory, initial runs can be made to establish the desired Mach number and pressure ratio in the tunnel.
7. The acquisition system used for reading the pressures in Reference 3 was the HP 3052/9845 portable system now used extensively in the subsonic cascade building. The software programs used there can be modified easily to accommodate the pressure tap arrangement in the transonic cascade.
8. With the HP 3052/9845 in place, the original aluminum side walls can be installed and connected to Scanivalves to obtain pressure data.

It is further recommended that the pressure tap arrangement in the original side walls be modified to cover the test region more completely. The pressure contours obtained will then be more accurate and allow comparison with analytically predicted contours such as can be generated by Eidelman. [Ref. 4]

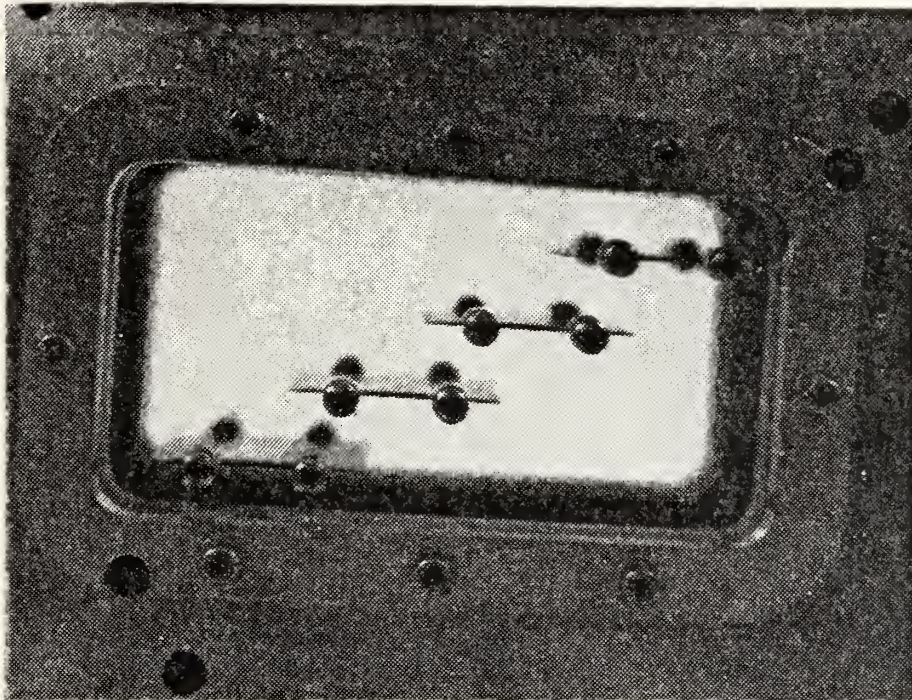
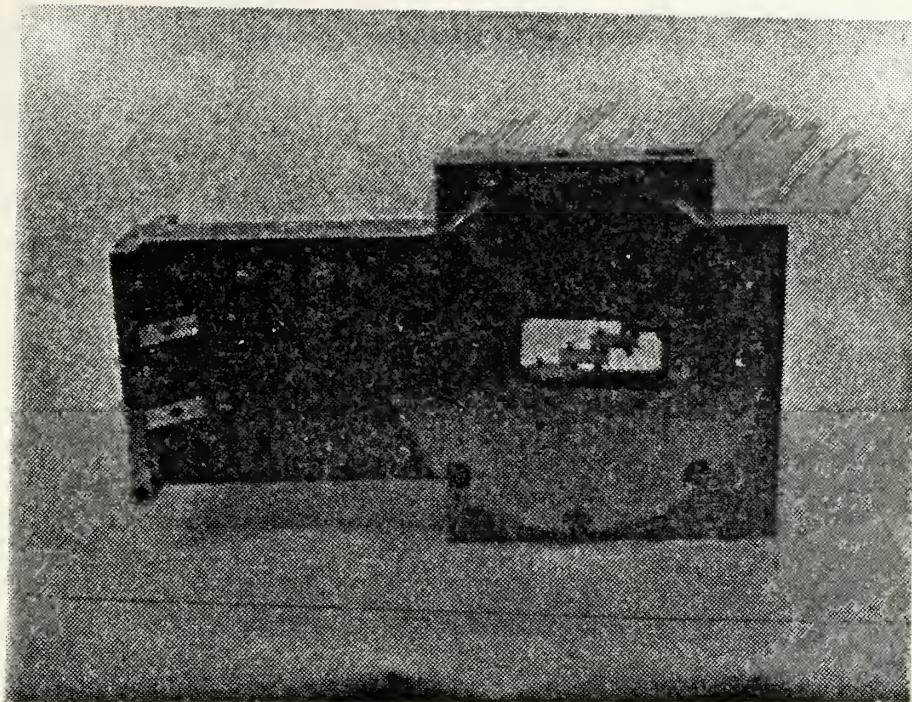
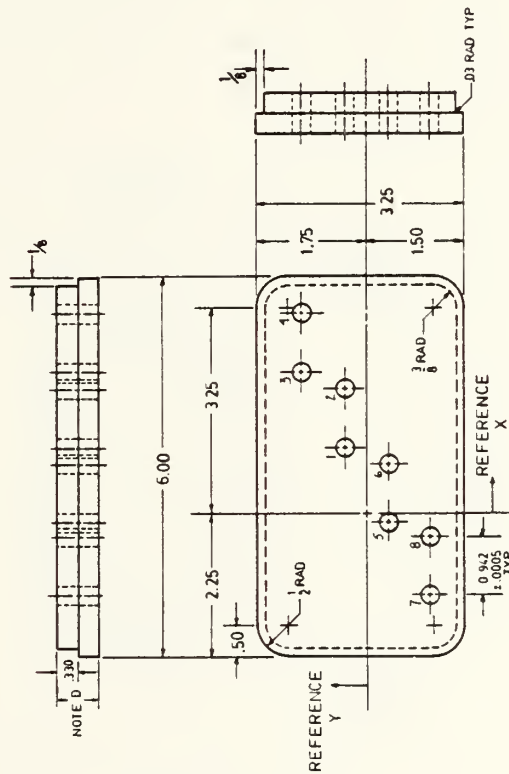


Figure C.1 Modified Test Section

C.4 DRAWINGS OF WINDOW MODIFICATIONS

The following pages contain:

<u>DWG No.</u>	<u>Title</u>
5111-2	Optical Glass Windows
5112-2	Window Supports
5113-2	Window Retainer Rings
5120	Window Gaskets



HOLE	X(in)	Y(in)
1	1.051	0.358
2	1.992	0.358
3	2.213	1.033
4	3.154	1.033
5	-0.110	-0.317
6	0.831	-0.317
7	-1.272	-0.993
8	-0.331	-0.993

NOTE A ALL HOLE DIAMETERS 0.311 IN.
MANUFACTURE LEFT AND RIGHT
HAND PARTS. RIGHT HAND SHOWN.

NOTE B PART NO. 5111-2A IS SHOWN,
OPPOSITE HAND PART NO. 5111-2B.

NOTE C BREAK ALL EDGES.

NOTE D OPTICALLY POLISHED GLASS FLAT,
13X6X0.067, TO BE PROVIDED. UNUSED
MATERIALS TO BE RETURNED. OPTICAL
SURFACES TO BE PROTECTED AND RETURNED
WITHOUT FLAW.

NAVAL POSTGRADUATE SCHOOL
DEPARTMENT OF AERONAUTICS TURBOPROPULSION LABORATORY
MONTEREY, CALIF. 93940

OPTICAL GLASS WINDOWS

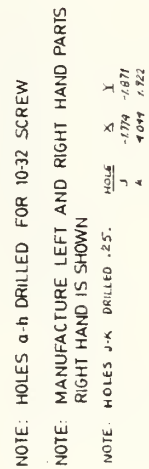
DESIGNED BY	27 OCTOBER 1987	DATE	1" ± 1"	SCALE	0.04 ± 0.05	0.04 ± 0.05	0.04 ± 0.05	0.04 ± 0.05
DRAWN BY	27 OCTOBER 1987	DATE	1" ± 1"	SCALE	0.04 ± 0.05	0.04 ± 0.05	0.04 ± 0.05	0.04 ± 0.05
CHECKED BY	27 OCTOBER 1987	DATE	1" ± 1"	SCALE	0.04 ± 0.05	0.04 ± 0.05	0.04 ± 0.05	0.04 ± 0.05
APPROVED BY	27 OCTOBER 1987	DATE	1" ± 1"	SCALE	0.04 ± 0.05	0.04 ± 0.05	0.04 ± 0.05	0.04 ± 0.05
5111-2								

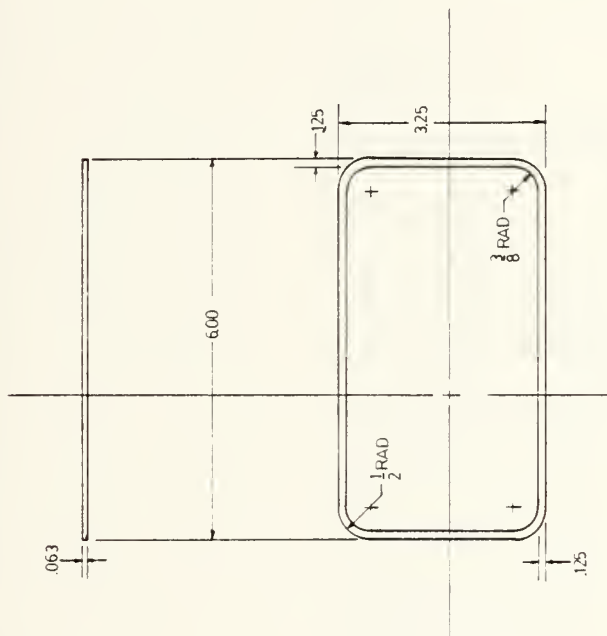


HOLES 1-4, DRILL THROUGH AT RADIUS SPECIFIED 0.480 DIA ±.001		
1	6.678	
2	5.036	
3	2.578	
4	2.968	

PART NO 5112-2C IS SHOWN
5112-2D IS OF OPPOSITE HAND

[illegible]

141



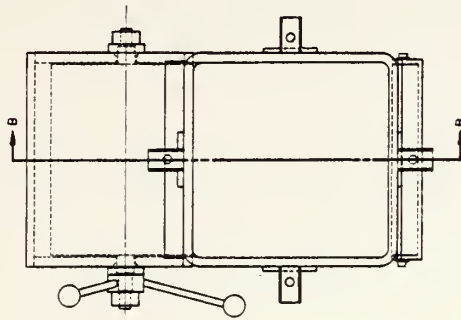
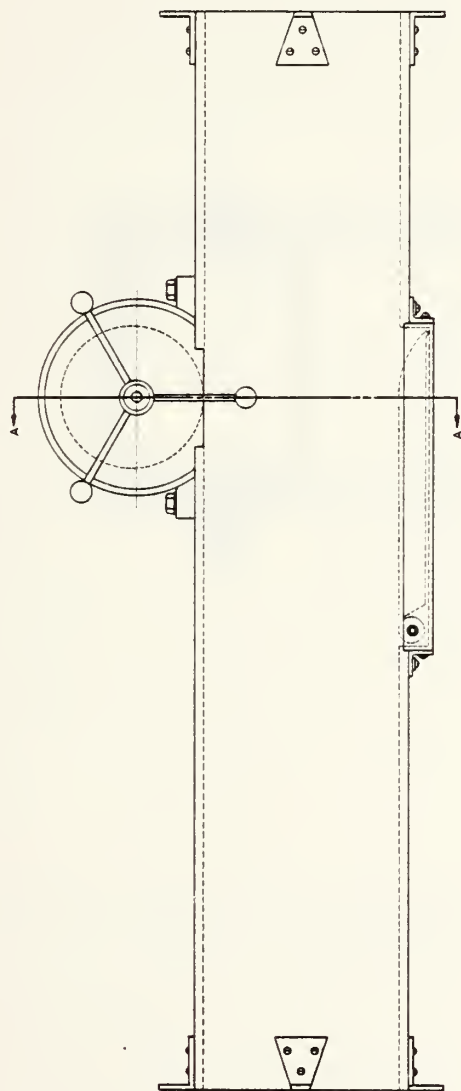
NOTE MANUFACTURE TWO PARTS, 5120A-B
FROM GASKET MATERIAL.
MANUFACTURE TWO PARTS, 5120C-D
FROM 1/16" SHEET TEFLON.

NAVAL POSTGRADUATE SCHOOL DEPARTMENT OF MECHANICAL ENGINEERING MORTMERE CALIF 95040	
WINDOW GASKETS	
DATE: 25 OCTOBER 1982	FIGURE: 1A
SCALE: 1" = 1"	UNIT: INCH
DESIGN: 5120A-B, C, D	DATE: 10/25/82
DRAWN: NO	5120
APPROVED: _____	

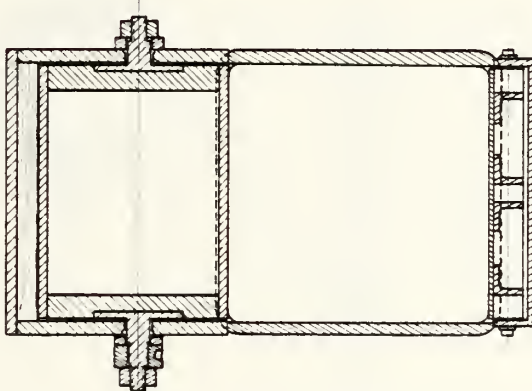
C.5 DRAWINGS OF THROTTLE VALVE

The following pages contain drawings of the throttle valve by A. G. McGuire and the author, namely:

<u>DWG No.</u>	<u>Title</u>
5118B	Throttle Valve Assembly
5121A	Throttling Plate
5122	Adjustable Cylinder
5123	Sliding Plate Rails
5124	Sliding Plate
5125	Throttling Plate Pan
5130	Spacer
5132	Shaft
5133	Adjusting Cylinder Assembly
5134	End Plate
5135	Outer Cylinder Housing
5136	Cylinder Mounts
5137	Attaching Cylinder Parts
5138	Throttle Duct
5139	Transition Section
5140	Transition End Plates
5141	Transition Sidewalls

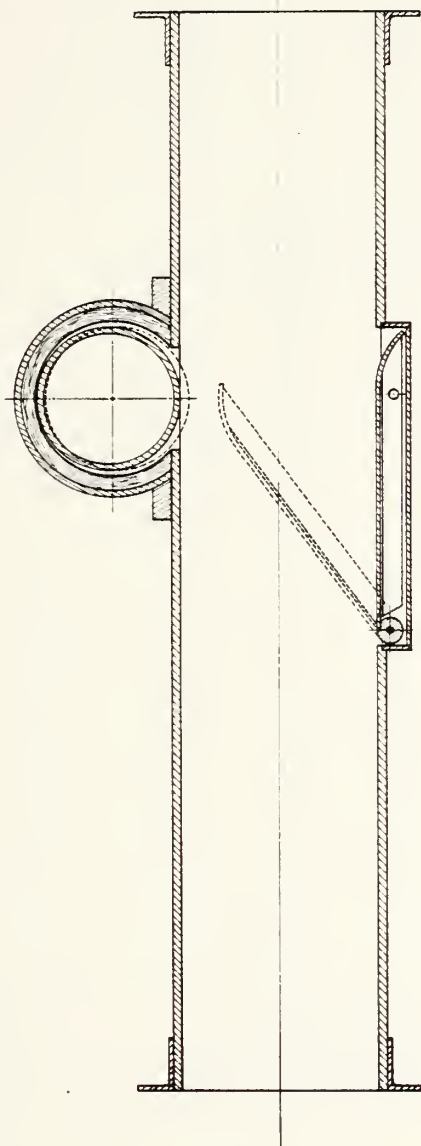


NAVY POST GRADUATE SCHOOL, MONTEREY, CALIF. 93940	
THROTTLE VALVE ASS'Y	
DESIGNED BY <i>STP</i>	DATE <i>2 APR 1961</i>
CHECKED BY <i>STP</i>	DATE <i>2 APR 1961</i>
APPROVED BY <i>STP</i>	DATE <i>2 APR 1961</i>
DRAWING NO. 5118B	SHEET 1 OF 3
TOLERANCES	
FRACTIONS	$\pm .005$
DIMENSIONS	$\pm .005$
ANGLES	$\pm .005$
SPACES	$\pm .005$



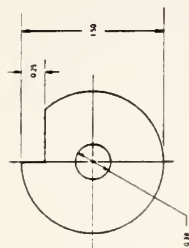
SECTION A-A

NAVAL POSTGRADUATE SCHOOL DEPARTMENT OF AERONAUTICS TURBOPROPELLSION LABORATORY MONTEREY, CALIF. 93940	
THROTTLE VALVE ASS'Y	
DRAWN BY <i>W. J. G. J. G.</i>	TOLERANCES
DATE 7 JUNE 1981	FRACTIONS - 2
SCALE 0.75" = 1.0"	DECIMALS
DIMENSIONS ARE IN INCHES	0.1 - 2
DRAWING NO 5118B	0.001 - 2
	ANGLES - .
	SHEET 2
	OF 3



SECTION B-B

NAVAL POSTGRADUATE SCHOOL DEPARTMENT OF MECHANICAL ENGINEERING MONTELEONE VALVE 9-10-60	
THROTTLE VALVE ASS'Y	
DESIGNED BY <i>ETP</i>	TELEBOUNCES
DATE <i>10-10-60</i>	FIGURES <i>1</i>
SCALE <i>AS SHOWN</i>	ANALYSIS
PRINTED BY <i>MECHANICAL</i>	QA <i>1</i>
UNAWARDED	QA <i>2</i>
	QA <i>3</i>
	QA <i>4</i>
	QA <i>5</i>
	QA <i>6</i>
	QA <i>7</i>
	QA <i>8</i>
	QA <i>9</i>
	QA <i>10</i>
	QA <i>11</i>
	QA <i>12</i>
	QA <i>13</i>
	QA <i>14</i>
	QA <i>15</i>
	QA <i>16</i>
	QA <i>17</i>
	QA <i>18</i>
	QA <i>19</i>
	QA <i>20</i>
	QA <i>21</i>
	QA <i>22</i>
	QA <i>23</i>
	QA <i>24</i>
	QA <i>25</i>
	QA <i>26</i>
	QA <i>27</i>
	QA <i>28</i>
	QA <i>29</i>
	QA <i>30</i>
	QA <i>31</i>
	QA <i>32</i>
	QA <i>33</i>
	QA <i>34</i>
	QA <i>35</i>
	QA <i>36</i>
	QA <i>37</i>
	QA <i>38</i>
	QA <i>39</i>
	QA <i>40</i>
	QA <i>41</i>
	QA <i>42</i>
	QA <i>43</i>
	QA <i>44</i>
	QA <i>45</i>
	QA <i>46</i>
	QA <i>47</i>
	QA <i>48</i>
	QA <i>49</i>
	QA <i>50</i>
	QA <i>51</i>
	QA <i>52</i>
	QA <i>53</i>
	QA <i>54</i>
	QA <i>55</i>
	QA <i>56</i>
	QA <i>57</i>
	QA <i>58</i>
	QA <i>59</i>
	QA <i>60</i>
	QA <i>61</i>
	QA <i>62</i>
	QA <i>63</i>
	QA <i>64</i>
	QA <i>65</i>
	QA <i>66</i>
	QA <i>67</i>
	QA <i>68</i>
	QA <i>69</i>
	QA <i>70</i>
	QA <i>71</i>
	QA <i>72</i>
	QA <i>73</i>
	QA <i>74</i>
	QA <i>75</i>
	QA <i>76</i>
	QA <i>77</i>
	QA <i>78</i>
	QA <i>79</i>
	QA <i>80</i>
	QA <i>81</i>
	QA <i>82</i>
	QA <i>83</i>
	QA <i>84</i>
	QA <i>85</i>
	QA <i>86</i>
	QA <i>87</i>
	QA <i>88</i>
	QA <i>89</i>
	QA <i>90</i>
	QA <i>91</i>
	QA <i>92</i>
	QA <i>93</i>
	QA <i>94</i>
	QA <i>95</i>
	QA <i>96</i>
	QA <i>97</i>
	QA <i>98</i>
	QA <i>99</i>
	QA <i>100</i>
	QA <i>101</i>
	QA <i>102</i>
	QA <i>103</i>
	QA <i>104</i>
	QA <i>105</i>
	QA <i>106</i>
	QA <i>107</i>
	QA <i>108</i>
	QA <i>109</i>
	QA <i>110</i>
	QA <i>111</i>
	QA <i>112</i>
	QA <i>113</i>
	QA <i>114</i>
	QA <i>115</i>
	QA <i>116</i>
	QA <i>117</i>
	QA <i>118</i>
	QA <i>119</i>
	QA <i>120</i>
	QA <i>121</i>
	QA <i>122</i>
	QA <i>123</i>
	QA <i>124</i>
	QA <i>125</i>
	QA <i>126</i>
	QA <i>127</i>
	QA <i>128</i>
	QA <i>129</i>
	QA <i>130</i>
	QA <i>131</i>
	QA <i>132</i>
	QA <i>133</i>
	QA <i>134</i>
	QA <i>135</i>
	QA <i>136</i>
	QA <i>137</i>
	QA <i>138</i>
	QA <i>139</i>
	QA <i>140</i>
	QA <i>141</i>
	QA <i>142</i>
	QA <i>143</i>
	QA <i>144</i>
	QA <i>145</i>
	QA <i>146</i>
	QA <i>147</i>
	QA <i>148</i>
	QA <i>149</i>
	QA <i>150</i>
	QA <i>151</i>
	QA <i>152</i>
	QA <i>153</i>
	QA <i>154</i>
	QA <i>155</i>
	QA <i>156</i>
	QA <i>157</i>
	QA <i>158</i>
	QA <i>159</i>
	QA <i>160</i>
	QA <i>161</i>
	QA <i>162</i>
	QA <i>163</i>
	QA <i>164</i>
	QA <i>165</i>
	QA <i>166</i>
	QA <i>167</i>
	QA <i>168</i>
	QA <i>169</i>
	QA <i>170</i>
	QA <i>171</i>
	QA <i>172</i>
	QA <i>173</i>
	QA <i>174</i>
	QA <i>175</i>
	QA <i>176</i>
	QA <i>177</i>
	QA <i>178</i>
	QA <i>179</i>
	QA <i>180</i>
	QA <i>181</i>
	QA <i>182</i>
	QA <i>183</i>
	QA <i>184</i>
	QA <i>185</i>
	QA <i>186</i>
	QA <i>187</i>
	QA <i>188</i>
	QA <i>189</i>
	QA <i>190</i>
	QA <i>191</i>
	QA <i>192</i>
	QA <i>193</i>
	QA <i>194</i>
	QA <i>195</i>
	QA <i>196</i>
	QA <i>197</i>
	QA <i>198</i>
	QA <i>199</i>
	QA <i>200</i>
	QA <i>201</i>
	QA <i>202</i>
	QA <i>203</i>
	QA <i>204</i>
	QA <i>205</i>
	QA <i>206</i>
	QA <i>207</i>
	QA <i>208</i>
	QA <i>209</i>
	QA <i>210</i>
	QA <i>211</i>
	QA <i>212</i>
	QA <i>213</i>
	QA <i>214</i>
	QA <i>215</i>
	QA <i>216</i>
	QA <i>217</i>
	QA <i>218</i>
	QA <i>219</i>
	QA <i>220</i>
	QA <i>221</i>
	QA <i>222</i>
	QA <i>223</i>
	QA <i>224</i>
	QA <i>225</i>
	QA <i>226</i>
	QA <i>227</i>
	QA <i>228</i>
	QA <i>229</i>
	QA <i>230</i>
	QA <i>231</i>
	QA <i>232</i>
	QA <i>233</i>
	QA <i>234</i>
	QA <i>235</i>
	QA <i>236</i>
	QA <i>237</i>
	QA <i>238</i>
	QA <i>239</i>
	QA <i>240</i>
	QA <i>241</i>
	QA <i>242</i>
	QA <i>243</i>
	QA <i>244</i>
	QA <i>245</i>
	QA <i>246</i>
	QA <i>247</i>
	QA <i>248</i>
	QA <i>249</i>
	QA <i>250</i>
	QA <i>251</i>
	QA <i>252</i>
	QA <i>253</i>
	QA <i>254</i>
	QA <i>255</i>
	QA <i>256</i>
	QA <i>257</i>
	QA <i>258</i>
	QA <i>259</i>
	QA <i>260</i>
	QA <i>261</i>
	QA <i>262</i>
	QA <i>263</i>
	QA <i>264</i>
	QA <i>265</i>
	QA <i>266</i>
	QA <i>267</i>
	QA <i>268</i>
	QA <i>269</i>
	QA <i>270</i>
	QA <i>271</i>
	QA <i>272</i>
	QA <i>273</i>
	QA <i>274</i>
	QA <i>275</i>
	QA <i>276</i>
	QA <i>277</i>
	QA <i>278</i>
	QA <i>279</i>
	QA <i>280</i>
	QA <i>281</i>
	QA <i>282</i>
	QA <i>283</i>
	QA <i>284</i>
	QA <i>285</i>
	QA <i>286</i>
	QA <i>287</i>
	QA <i>288</i>
	QA <i>289</i>
	QA <i>290</i>
	QA <i>291</i>
	QA <i>292</i>
	QA <i>293</i>
	QA <i>294</i>
	QA <i>295</i>
	QA <i>296</i>
	QA <i>297</i>
	QA <i>298</i>
	QA <i>299</i>
	QA <i>300</i>
	QA <i>301</i>
	QA <i>302</i>
	QA <i>303</i>
	QA <i>304</i>
	QA <i>305</i>
	QA <i>306</i>
	QA <i>307</i>
	QA <i>308</i>
	QA <i>309</i>
	QA <i>310</i>
	QA <i>311</i>
	QA <i>312</i>
	QA <i>313</i>
	QA <i>314</i>
	QA <i>315</i>
	QA <i>316</i>
	QA <i>317</i>
	QA <i>318</i>
	QA <i>319</i>
	QA <i>320</i>
	QA <i>321</i>
	QA <i>322</i>
	QA <i>323</i>
	QA <i>324</i>
	QA <i>325</i>
	QA <i>326</i>
	QA <i>327</i>
	QA <i>328</i>
	QA <i>329</i>
	QA <i>330</i>
	QA <i>331</i>
	QA <i>332</i>
	QA <i>333</i>
	QA <i>334</i>
	QA <i>335</i>
	QA <i>336</i>
	QA <i>337</i>
	QA <i>338</i>
	QA <i>339</i>
	QA <i>340</i>
	QA <i>341</i>
	QA <i>342</i>
	QA <i>343</i>
	QA <i>344</i>
	QA <i>345</i>
	QA <i>346</i>
	QA <i>347</i>
	QA <i>348</i>
	QA <i>349</i>
	QA <i>350</i>
	QA <i>351</i>
	QA <i>352</i>
	QA <i>353</i>
	QA <i>354</i>
	QA <i>355</i>
	QA <i>356</i>
	QA <i>357</i>
	QA <i>358</i>
	QA <i>359</i>
	QA <i>360</i>
	QA <i>361</i>
	QA <i>362</i>
	QA <i>363</i>
	QA <i>364</i>
	QA <i>365</i>
	QA <i>366</i>
	QA <i>367</i>
	QA <i>368</i>
	QA <i>369</i>
	QA <i>370</i>
	QA <i>371</i>
	QA <i>372</i>
	QA <i>373</i>
	QA <i>374</i>
	QA <i>375</i>
	QA <i>376</i>
	QA <i>377</i>
	QA <i>378</i>
	QA <i>379</i>
	QA <i>380</i>
	QA <i>381</i>
	QA <i>382</i>
	QA <i>383</i>
	QA <i>384</i>
	QA <i>385</i>
	QA <i>386</i>
	QA <i>387</i>
	QA <i>388</i>
	QA <i>389</i>
	QA <i>390</i>
	QA <i>391</i>
	QA <i>392</i>
	QA <i>393</i>
	QA <i>394</i>
	QA <i>395</i>
	QA <i>396</i>
	QA <i>397</i>
	QA <i>398</i>
	QA <i>399</i>
	QA <i>400</i>
	QA <i>401</i>
	QA <i>402</i>
	QA <i>403</i>
	QA <i>404</i>
	QA <i>405</i>
	QA <i>406</i>
	QA <i>407</i>
	QA <i>408</i>
	QA <i>409</i>
	QA <i>410</i>
	QA <i>411</i>
	QA <i>412</i>
	QA <i>413</i>
	QA <i>414</i>
	QA <i>415</i>
	QA <i>416</i>
	QA <i>417</i>
	QA <i>418</i>
	QA <i>419</i>
	QA <i>420</i>
	QA <i>421</i>
	QA <i>422</i>
	QA <i>423</i>
	QA <i>424</i>
	QA <i>425</i>
	QA <i>426</i>
	QA <i>427</i>
	QA <i>428</i>
	QA <i>429</i>
	QA <i>430</i>
	QA <i>431</i>
	QA <i>432</i>
	QA <i>433</i>
	QA <i>434</i>
	QA <i>435</i>
	QA <i>436</i>
	QA <i>437</i>
	QA <i>438</i>
	QA <i>439</i>
	QA <i>440</i>
	QA <i>441</i>
	QA <i>442</i>
	QA <i>443</i>
	QA <i>444</i>
	QA <i>445</i>
	QA <i>446</i>
	QA <i>447</i>

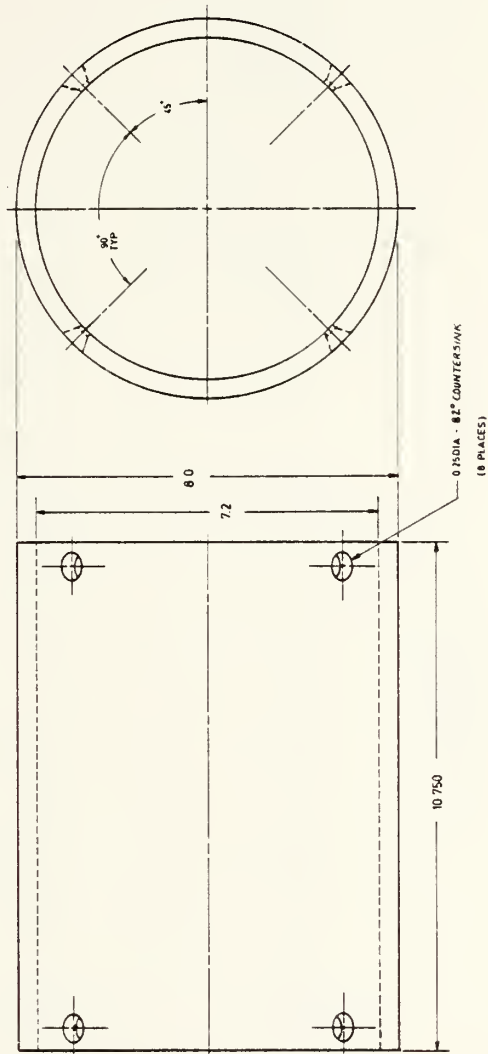


2X SCALE

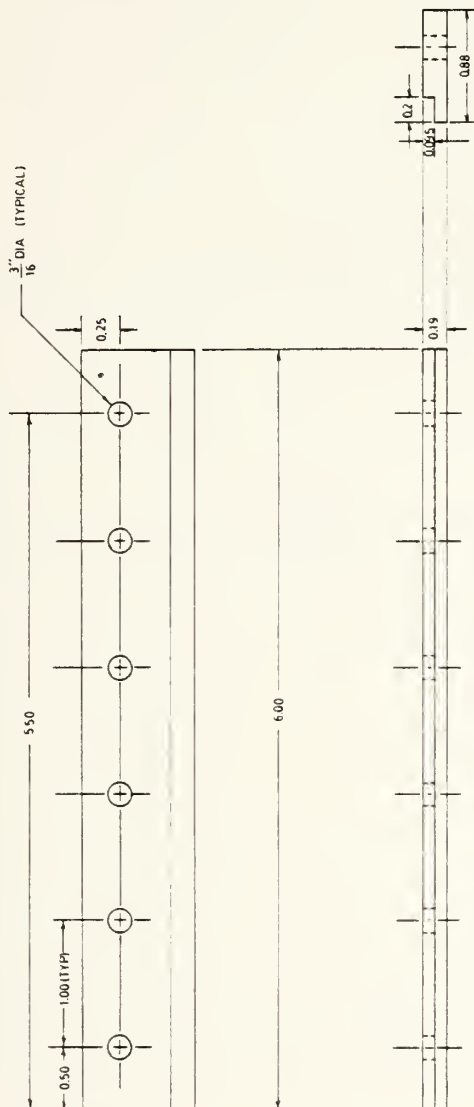
- ① STIFFENERS ARE STANDARD L₂ X 1/2 X 1/8 ANGLE STOCK CUT TO FIT CURVATURE AND LENGTH OF THE RAMP
- ② SECURE PLATE IN PLACE WITH A MINIMUM OF TEN, EQUALLY SPACED, 8-18 X 1/2 SCREWS BEFORE WELDING (COUNTERSUNK)
- ③ WELD TYPICAL OF ALL STIFFENERS

NATIONAL INSTITUTE OF STANDARDS DEPARTMENT OF AERONAUTICS, TECHNOLOGICAL LABORATORY MONTELEONE CALIF. 93040	
THROTTLING PLATE	
DRAWN BY: <i>J. E. Smith</i>	TOLERANCES
DATE: 8 JAN 1963	FRACTIONS ± .2
SCALE: FULL	DECIMALS
DIMENSIONS SET IN INCHES	0+/- = 2 000
DRAWING NO. 5121A	0- = 2 000
	0.000 + 2 000
	0.000 - 2 000
	SHEET 1 OF 1

MATERIAL
MILD STEEL

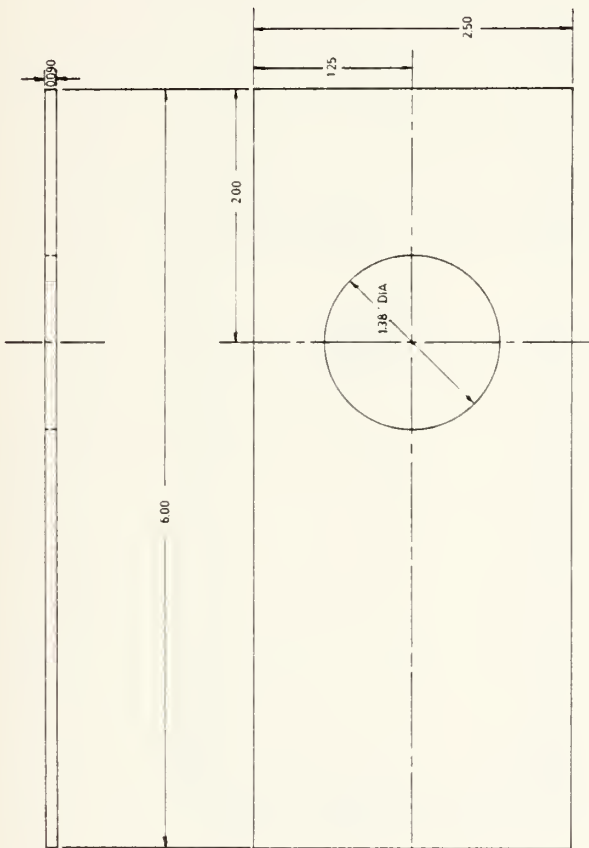


NAVAL POSTGRADUATE SCHOOL DEPARTMENT OF AERONAUTICS TURBOPROPULSION LABORATORY MONTEREY CALIF 93940	
ADJUSTABLE CYLINDER	
DRAWN BY <i>W. J. G. G. G.</i>	TOLERANCES
DATE 17 JAN 1961	FRACTIONS $\pm \frac{1}{64}$
SCALE $\frac{3}{4}'' = 1''$	DECIMALS
DIMENSIONS ARE IN INCHES	0.1 ± 0.05
	0.01 ± 0.005
	0.001 ± 0.001
	ANGLES $\pm 0.5^\circ$
MATERIAL SEAMLESS TUBING	DRAWING NO. 5122
	SHEET 1 OF 2

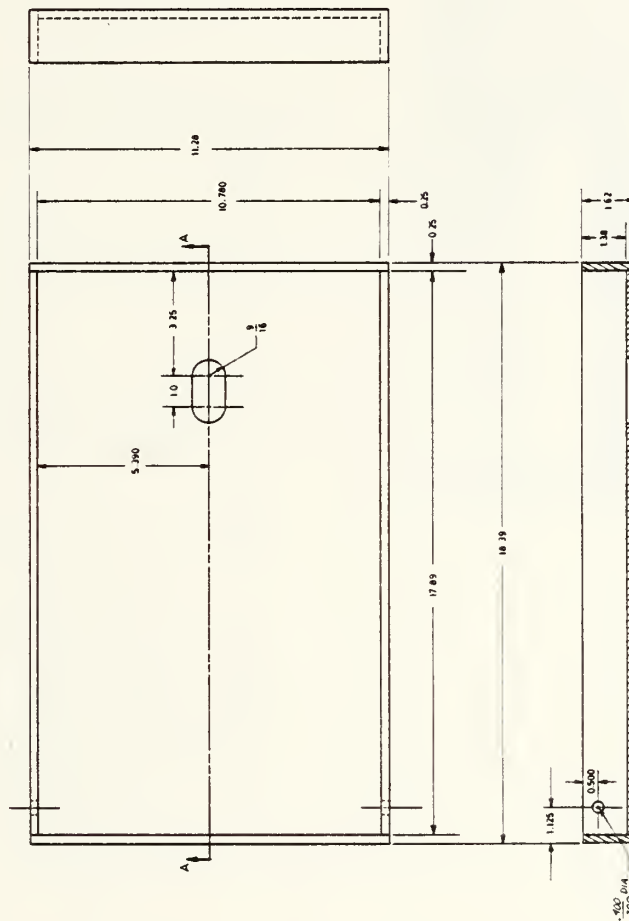


NOTE MANUFACTURE TWO PARTS
FROM ALUMINUM

SLIDING PLATE RAILS		A	
APR 1982		.05	
30 DECEMBER 1982		.005	
2X		.001	
MATERIAL		5123	

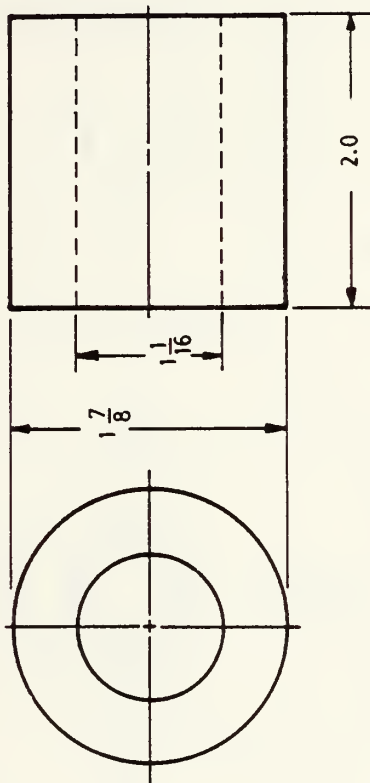


FOR: P. ZACHARAT, JR. A. A. HOFFMAN INDUSTRIES, INC. 1000 S. 10TH AVE., SUITE 100 DENVER, CO. 80202	
SLIDING PLATE	
DATE: 30 DECEMBER 1982	BY: J. J. BROWN
2 X	1/2 X 1/2 X 1/2
5124	
MATERIAL: 2024-T3 ALUMINUM	
DIMENSIONS: 6.00 ± .005 2.50 ± .005 2.00 ± .005 1.25 ± .005 1.38 ± .005	FINISH: ANODIZED



NOTE: WELD ALL SEAMS WITH DOUBLE BEVEL

NAVAL POSTGRADUATE SCHOOL DEPARTMENT OF AERONAUTICS, TURBOPROPULSION LABORATORY MONTEREY, CALIF. 93940		THROTTLING PLATE PAN	
DRAWN BY	G. J. H. G. G.	TOLERANCES	
DATE	14 JAN 1942	FRACTIONS	$\pm \frac{1}{32}$
SCALE	HALF	DECIMALS	0.1 - ± 0.05
DIMENSIONS ARE IN INCHES		0.01 - ± 0.005	
DRAWING NO.		0.001 - ± 0.001	
5125		ANGLES	° ' "
MATERIAL	MILD STEEL	SHEET	
		OF	



NAVAL POSTGRADUATE SCHOOL
DEPARTMENT OF AERONAUTICS, TURBOPROPULSION LABORATORY
MONTEREY, CALIF. 93940

SPACER

DRAWN BY *D. S. McQuire*

DATE 1 FEB 1983

SCALE FULL

DIMENSIONS ARE IN INCHES

DRAWING NO.

5130

MATERIAL

MILD STEEL

TOLERANCES

FRACTIONS = $\pm \frac{1}{32}$

DECIMALS

0.X = ± 0.05

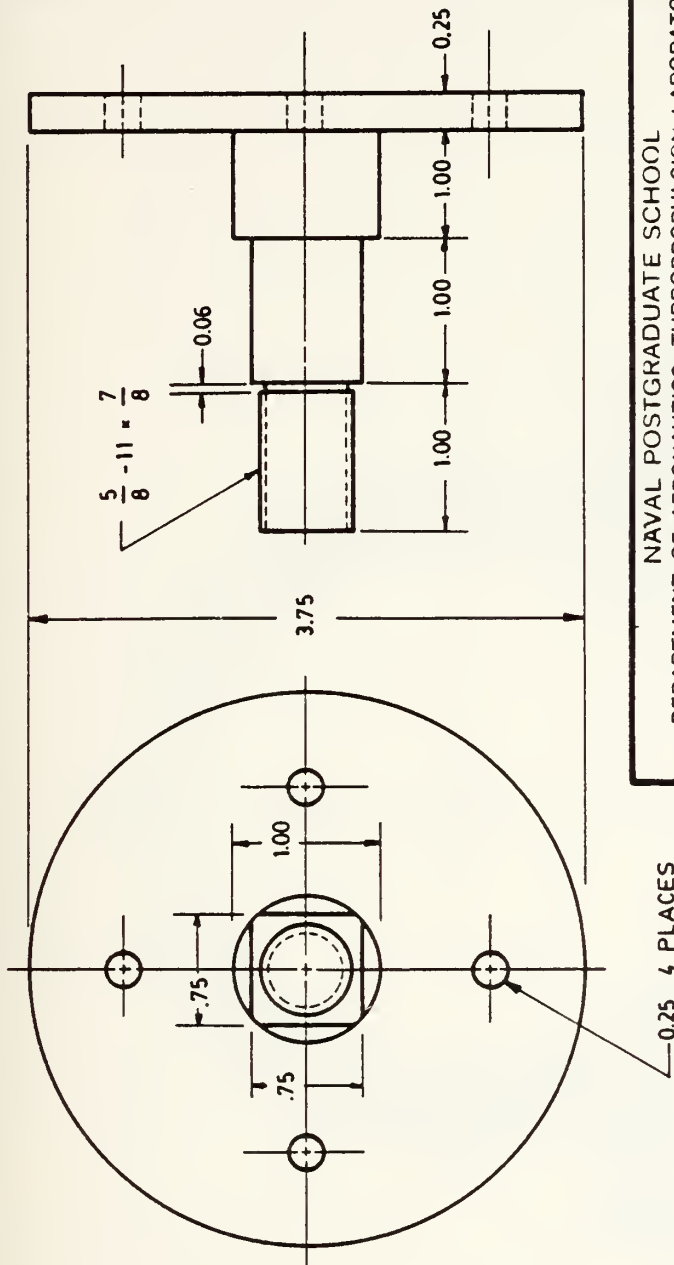
0.XX = ± 0.005

0.XXX = \pm

ANGLES = $^{\circ}$

SHEET

OF



NAVAL POSTGRADUATE SCHOOL
DEPARTMENT OF AERONAUTICS, TURBOPROPULSION LABORATORY
MONTEREY, CALIF. 93940

SHAFT

DRAWN BY *L. G. McGuire*

DATE 23 FEB 1983

SCALE FULL

DIMENSIONS ARE IN INCHES

DRAWING NO.

5132

TOLERANCES

FRACTIONS = $\pm \frac{1}{32}$

DECIMALS

0.X = \pm

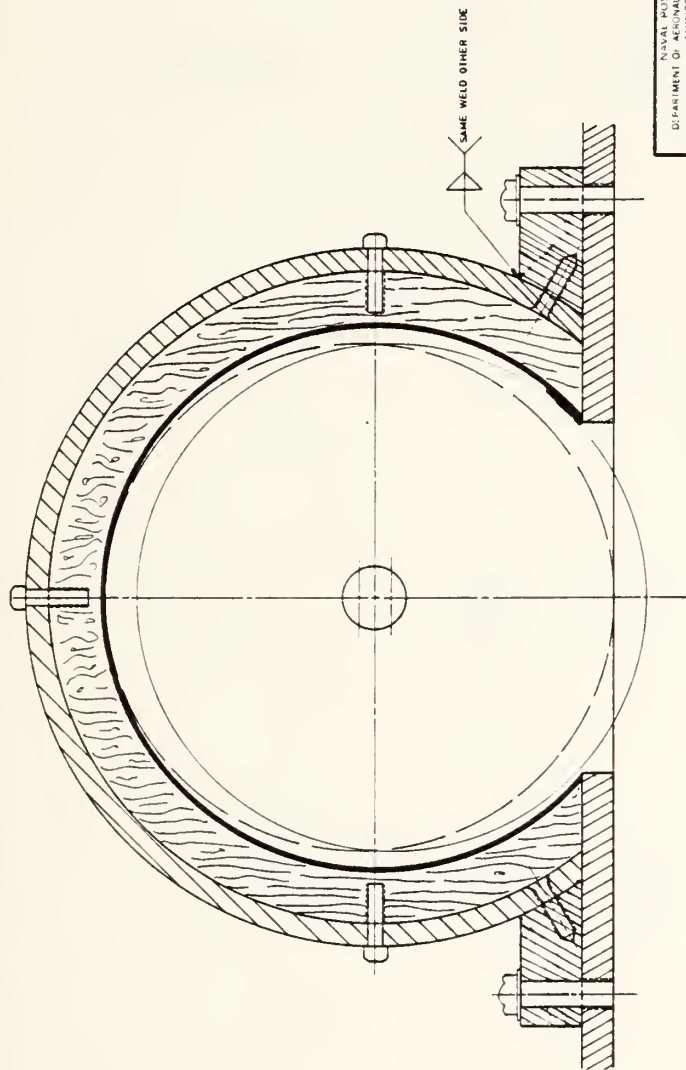
0.XX = ± 0.005

0.XXX = \pm

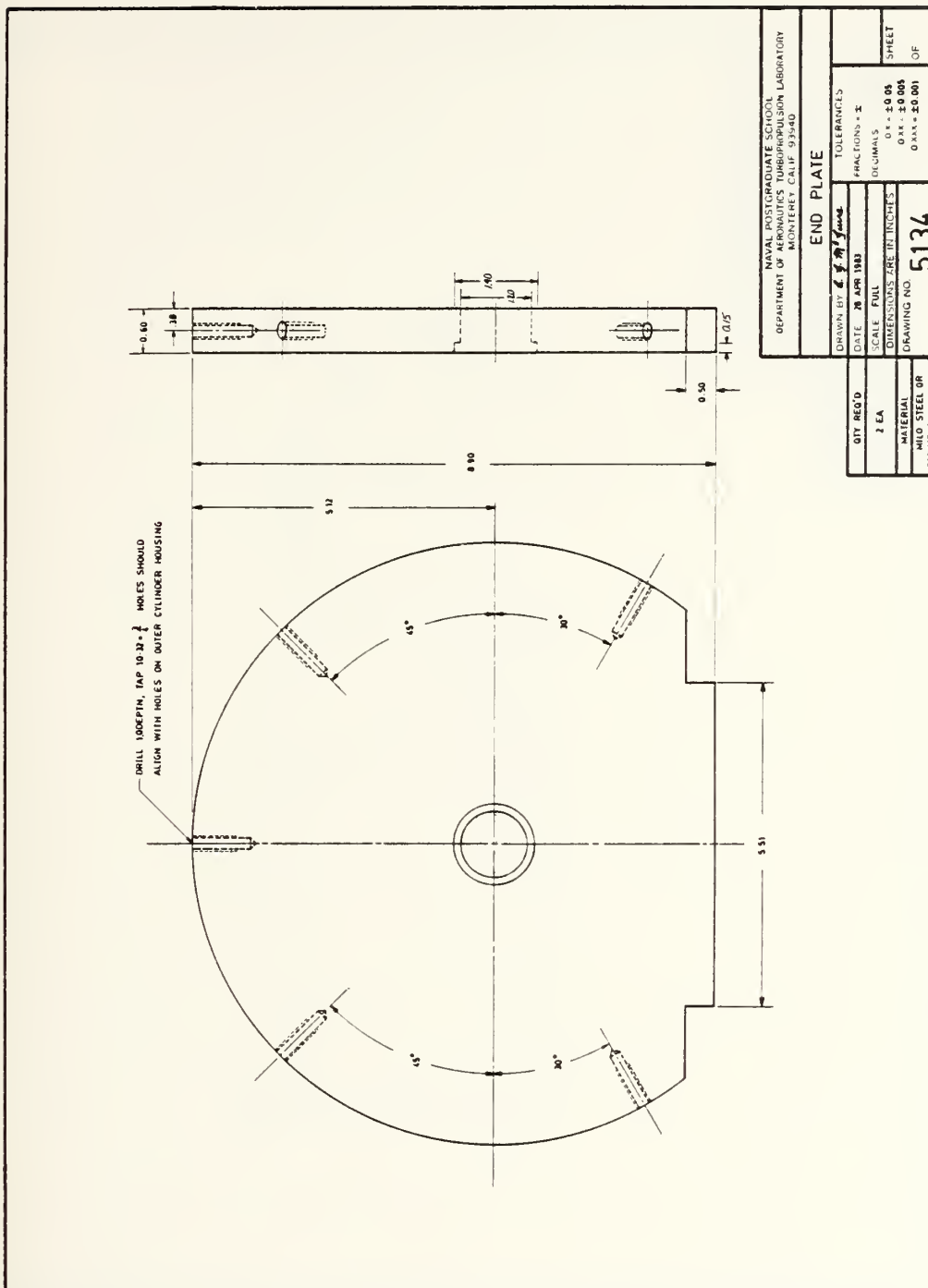
ANGLES = $^{\circ}$

SHEET

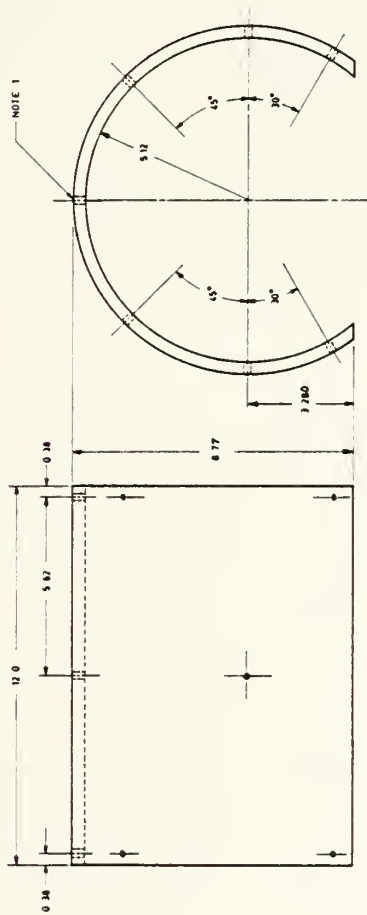
OF



NAVAL POSTGRADUATE SCHOOL DEPARTMENT OF AERONAUTICS TURBOMACHINERY LABORATORY MONTEREY, CALIF. 93940	
ADJUSTING CYLINDER ASSEMBLY	
DRAWN BY <i>A. H. J.</i>	
DATE 26 APR 1963	TOLERANCES
	FRACTIONS $\pm .001$
	DECIMALS $\pm .001$
SHEET FULL	DECIMALS $\pm .001$
DIMENSIONS ARE IN INCHES	DECIMALS $\pm .001$
DRAWING NO 5133	ANGLES $\pm .1$
	SHEET 1 OF 1

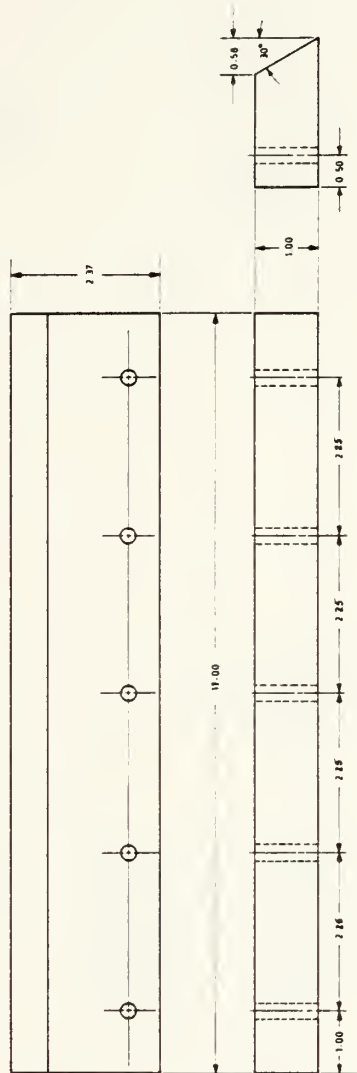


NAVAL POSTGRADUATE SCHOOL DEPARTMENT OF MECHANICAL ENGINEERING MONTEREY, CALIF. 93940		TOLERANCES FRACTIONS \pm 1 DECIMALS 0.1 \pm 0.05 0.01 \pm 0.005 0.001 \pm 0.001 ANGLES \pm 0.5°	
DRAWN BY <i>E. J. Smith</i> DATE 28 APR 1983 SCALE FULL DIMENSIONS ARE IN INCHES DRAWING NO. 5134		END PLATE	
QTY REQ'D 2 EA	MATERIAL MILO STEEL OR STRUCTURAL ALUMINUM	SHEET OF	



NOTE 1 DRILL ALL HOLES $\frac{1}{32}$

NAVAL POSTGRADUATE SCHOOL DEPARTMENT OF AERONAUTICS TURBOPROPULSION LABORATORY MONTEREY, CALIF. 95060	
OUTER CYLINDER HOUSING	
DRAWN BY <i>J. J. J.</i>	TOLERANCES
DATE 4 MAY 1968	FRACTIONS - \pm
SCALE HALF	DECIMALS
DIMENSIONS ARE IN INCHES	
DRAWING NO. 5135	SHOLET
MATERIAL 1100A $\frac{1}{2}$ ALUMINUM 106E	0.01 \pm 0.01 0.001 \pm 0.001 0.001 \pm 0.001 ANGLES \pm 0.5°

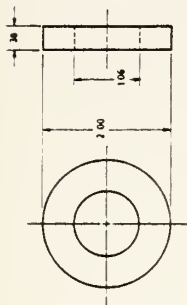


DRILL ALL HOLES 0.25

NAVAL POSTGRADUATE SCHOOL
DEPARTMENT OF AERONAUTICS TURBOPROPULSION LABORATORY
MONTEREY CALIF 93940

CYLINDER MOUNTS

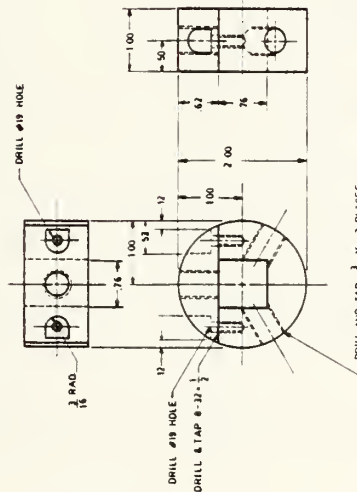
DRAWN BY <i>W. H. Jones</i>		TOLERANCES		SHEET
DATE 4 MAY 1983		FRACTIONS = 2		
SCALE FULL		DECIMALS		OF
DIMENSIONS ARE IN INCHES		0.1 ± 0.05 0.125 ± 0.01 0.006 ± 2 ANGLES = 0.5°		
DRAWING NO 5136				
MATERIAL ALUMINUM				



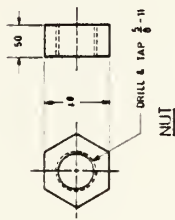
SPACER



(3 REQ'D)

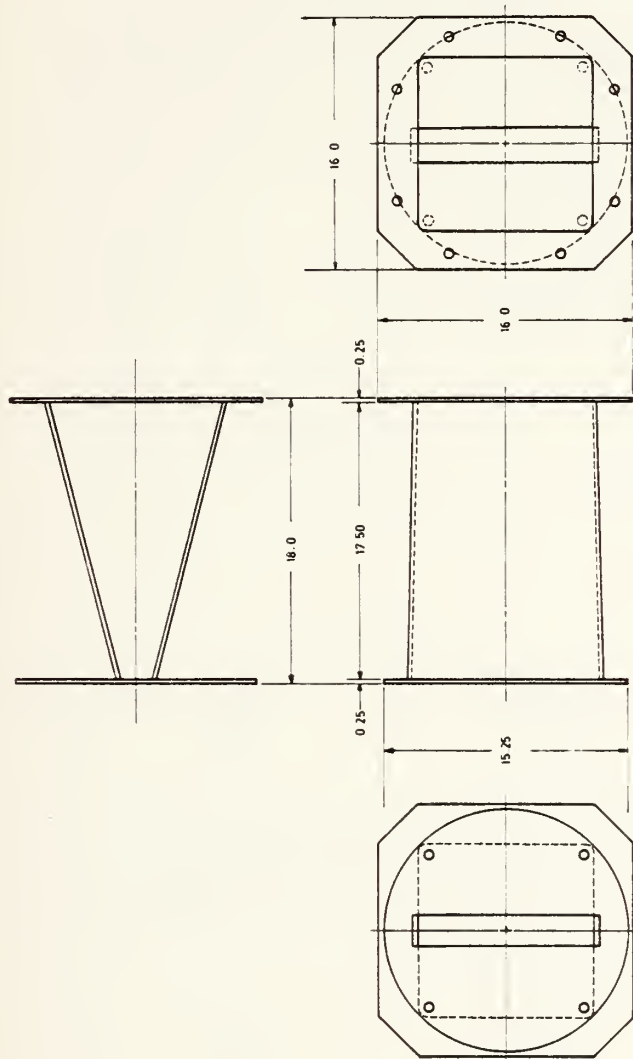


CONTROL WHEEL HUB
(ONLY ONE REQUIRED)



NUT

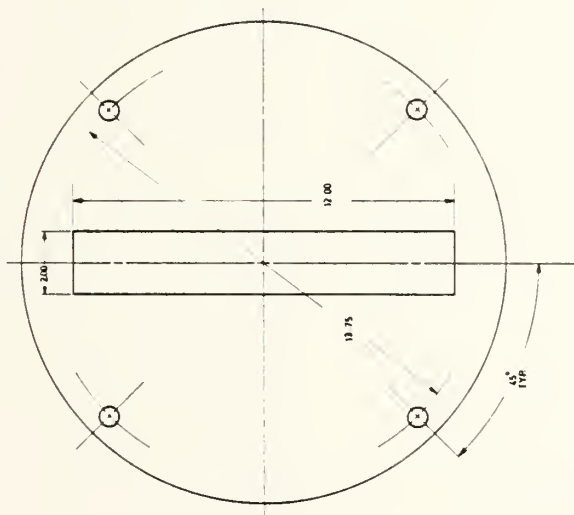
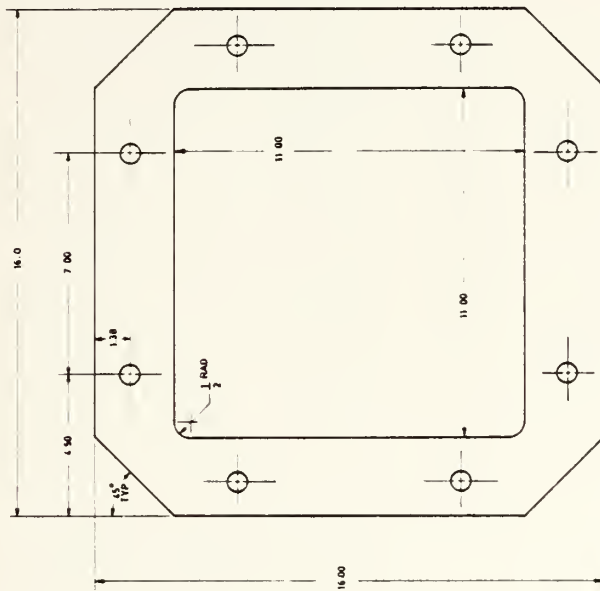
NAVAL POSTGRADUATE SCHOOL DEPARTMENT OF MECHANICAL ENGINEERING MONTEREY, CALIF. 93940		ATTACHING CYLINDER PARTS	
QTY REQ'D	DATE	DESIGNED BY	TOLERANCES
2 EA PER UNIT	27 JUNE 1983	D. J. M. G. M.	FRACTIONS - ±
MATERIAL	SCALE	FULL	DECIMALS
STEEL	DIMENSIONS ARE IN INCHES		0.1 ± ±0.05
	DRAWING NO	5137	0.01 ± ±0.005
			ANGLES
			OF
			SHEET



NOTE: EXTERNAL WELD ALL JOINTS

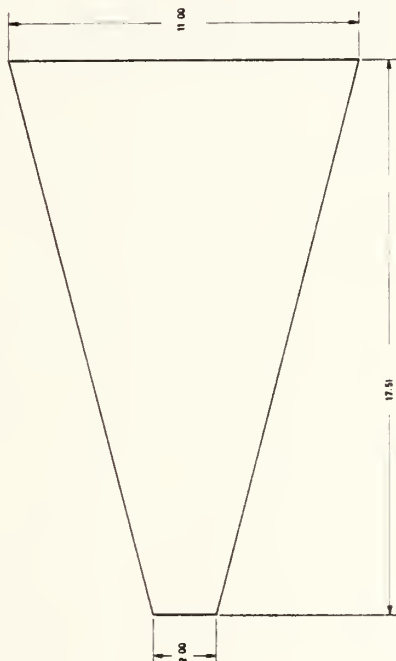
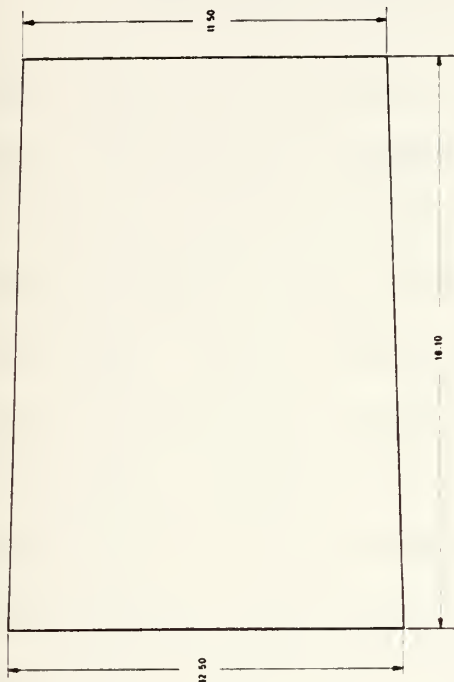
NAVAL POSTGRADUATE SCHOOL DEPARTMENT OF AERONAUTICS, TURBOPROPULSION LABORATORY PROJECT DATE: 9/9/80	
TRANSITION SECTION	
DRAWN BY <i>J. J. Jones</i>	TOLERANCES
DATE 21 JULY 1983	FRACTIONS \pm
SCALE 1/4"	DECIMALS
DIMENSIONS ARE IN INCHES	0.1 \pm
DRAWING NO. 5139	0.001 \pm
MATERIAL	ANGLES
MILD STEEL	

SHEET	OF
5	7



NOTE: DRILL ALL HOLES $\frac{1}{8}$ DIA

NAVAL POSTGRADUATE SCHOOL DEPARTMENT OF AERONAUTICS, TURBOPROPULSION LABORATORY MONTEREY, CALIF. 93940	
TRANSITION ENDPLATES	
DRAWN BY <i>J. J. Smith</i>	TOLERANCES ±
DATE 21 JULY 1963	FRACTIONS ±
SCALE 1/2"	DECIMALS ±
DIMENSIONS ARE IN INCHES	
DRAWING NO. 5140	ANGLES ±
MATERIAL	SHEET
1" STEEL PLATE	OF



NAVAL POSTGRADUATE SCHOOL DEPARTMENT OF AERONAUTICS, TURBOPROPULSION LABORATORY MONTEREY, CALIF. 93940		TRANSITION SIDEWALLS	
DRAWN BY <i>B. G. McFarlane</i> DATE 22 JULY 1983 SCALE 1/2 DIMENSIONS IN INCHES DRAWING NO 5141	TOLERANCES FINISHES ± DEC. 100 ± 5 DEC. 10 ± 2 DEC. 1 ± 0.005 DEC. 0.1 ± 0.001 DEC. 0.01 ± 0.0005 DEC. 0.001 ± 0.0001	SHEET OF	
QTY REQ'D 2 EACH MATERIAL 1/4 STEEL PLATE	5141		

APPENDIX D

DATA SET FOR 70% RPM, OPEN THROTTLE

This appendix contains a listing of the one complete set of data and reduced parameters. The data in the first twelve files were transcribed from files W54501 to W54512 obtained by program WKAQN on the HP 21MX Data Acquisition System to the IBM 3033. The following tables contain the values of pressure in units of inches of water that were used to qualitatively inspect the data. The third set of tables contain the file of pressures after they had been expanded to 16 x 256 arrays. The final set of tables contain the pressure coefficients that were plotted as contours and also compared with the analytical solution.

AVERAGE UNSTEADY WALL PRESSURE DATA -- FILE - W54501

-.1737	-.1792	-.1714	-.1768	-.1789	-.1708	-.1734	-.1727
-.1730	-.1740	-.1820	-.1768	-.1770	-.1815	-.1809	-.1828
-.1851	-.1807	-.1824	-.1916	-.1866	-.1870	-.1875	-.1885
-.1881	-.1833	-.1928	-.1904	-.1991	-.1972	-.1930	-.1966
-.1988	-.1999	-.2014	-.1966	-.2051	-.2031	-.1994	-.2000
-.2040	-.2007	-.2029	-.2023	-.2064	-.2074	-.2106	-.2138
-.2099	-.2132	-.2133	-.2071	-.2086	-.2152	-.2149	-.2182
-.2175	-.2132	-.2218	-.2207	-.2182	-.2210	-.2143	-.2183
-.2222	-.2231	-.2217	-.2225	-.2219	-.2289	-.2157	-.2294
-.2242	-.2337	-.2156	-.2130	-.2285	-.2191	-.2143	-.2299
-.2143	-.2146	-.2066	-.2172	-.2066	-.1985	-.1995	-.1881
-.2007	-.2055	-.2003	-.1994	-.1969	-.1911	-.1919	-.1951
-.1928	-.1889	-.1865	-.1927	-.1863	-.1898	-.1909	-.1937
-.1949	-.1978	-.1962	-.1855	-.1896	-.1925	-.1934	-.1944
-.1982	-.1889	-.1905	-.1881	-.1953	-.1877	-.1854	-.1847
-.1794	-.1806	-.1758	-.1801	-.1802	-.1874	-.1793	-.1816
-.1794	-.1696	-.1842	-.1780	-.1725	-.1685	-.1725	-.1816
-.1717	-.1679	-.1691	-.1756	-.1768	-.1780	-.1766	-.1762
-.1788	-.1797	-.1852	-.1894	-.1800	-.1888	-.1866	-.1875
-.1845	-.1898	-.1878	-.1917	-.1918	-.1868	-.1905	-.1915
-.1985	-.1911	-.1922	-.1961	-.1963	-.1959	-.1911	-.2000
-.2036	-.1952	-.1967	-.1976	-.1989	-.1955	-.2026	-.1990
-.2003	-.2031	-.2009	-.2015	-.2025	-.2087	-.2119	-.2042
-.2074	-.2091	-.2123	-.2116	-.2094	-.2165	-.2185	-.2166
-.2129	-.2137	-.2148	-.2092	-.2171	-.2085	-.2106	-.2101
-.2059	-.2121	-.2175	-.2078	-.2139	-.2106	-.2018	-.1945
-.1965	-.1969	-.1911	-.2034	-.1985	-.1866	-.1905	-.1902
-.1972	-.1761	-.1865	-.1920	-.1873	-.1789	-.1888	-.1863
-.1848	-.1850	-.1864	-.1765	-.1832	-.1838	-.1926	-.1777
-.1900	-.1891	-.1868	-.1855	-.1875	-.1917	-.1923	-.1866
-.1931	-.1863	-.1865	-.1881	-.1902	-.1825	-.1820	-.1818
-.1738	-.1896	-.1783	-.1845	-.1777	-.1742	-.1766	-.1714

AVERAGE UNSTEADY WALL PRESSURE DATA -- FILE - W54502

-.1692	-.1756	-.1678	-.1768	-.1712	-.1809	-.1795	-.1878
-.1873	-.1930	-.1884	-.1852	-.1946	-.1886	-.1984	-.2112
-.1954	-.1944	-.1981	-.2063	-.2082	-.2077	-.2113	-.2084
-.2179	-.2178	-.2207	-.2238	-.2238	-.2291	-.2340	-.2327
-.2360	-.2347	-.2396	-.2452	-.2438	-.2476	-.2502	-.2524
-.2505	-.2542	-.2552	-.2582	-.2631	-.2650	-.2662	-.2640
-.2614	-.2663	-.2656	-.2718	-.2731	-.2728	-.2720	-.2818
-.2735	-.2702	-.2827	-.2789	-.2613	-.2627	-.2603	-.2609
-.2709	-.2799	-.2510	-.2588	-.2467	-.2470	-.2310	-.2574
-.2320	-.2219	-.2427	-.2147	-.2267	-.2186	-.2269	-.2082
-.2162	-.2057	-.2137	-.1888	-.2150	-.2040	-.2095	-.2009
-.1982	-.2054	-.2134	-.1971	-.1890	-.1750	-.1871	-.1744
-.1924	-.1625	-.1613	-.1679	-.1648	-.1750	-.1694	-.1602
-.1618	-.1740	-.1594	-.1672	-.1714	-.1712	-.1642	-.1698
-.1713	-.1742	-.1728	-.1681	-.1607	-.1714	-.1658	-.1690
-.1681	-.1646	-.1698	-.1606	-.1638	-.1640	-.1724	-.1774
-.1727	-.1714	-.1801	-.1720	-.1827	-.1824	-.1761	-.1837
-.1849	-.1904	-.1887	-.1868	-.1885	-.1928	-.1931	-.1987
-.1972	-.1984	-.2011	-.2042	-.2027	-.2051	-.2110	-.2138
-.2127	-.2140	-.2148	-.2162	-.2190	-.2160	-.2274	-.2257
-.2266	-.2303	-.2339	-.2333	-.2347	-.2365	-.2353	-.2324
-.2398	-.2406	-.2443	-.2384	-.2447	-.2443	-.2440	-.2455
-.2495	-.2463	-.2414	-.2447	-.2455	-.2508	-.2426	-.2448
-.2507	-.2483	-.2440	-.2427	-.2530	-.2435	-.2346	-.2249
-.2300	-.2416	-.2200	-.2272	-.2212	-.2215	-.2143	-.2076
-.2128	-.2153	-.2053	-.2142	-.2090	-.2098	-.2065	-.2089
-.2130	-.2124	-.2110	-.1996	-.2095	-.1892	-.1927	-.2034
-.2039	-.1913	-.1728	-.1969	-.1903	-.1792	-.1691	-.1853
-.1671	-.1790	-.1730	-.1760	-.1675	-.1594	-.1691	-.1562
-.1597	-.1660	-.1700	-.1728	-.1598	-.1742	-.1698	-.1663
-.1629	-.1642	-.1702	-.1693	-.1661	-.1647	-.1653	-.1680
-.1696	-.1719	-.1628	-.1679	-.1590	-.1665	-.1708	-.1646

AVERAGE UNSTEADY WALL PRESSURE DATA -- FILE - W54503

-.1784	-.1766	-.1860	-.1822	-.2000	-.1900	-.2056	-.2046
-.2124	-.2222	-.2152	-.2214	-.2323	-.2374	-.2381	-.2430
-.2533	-.2564	-.2590	-.2604	-.2662	-.2698	-.2791	-.2889
-.2817	-.2894	-.2940	-.2969	-.2980	-.3003	-.3083	-.3147
-.3140	-.3140	-.3232	-.3219	-.3294	-.3267	-.3290	-.3299
-.3324	-.3377	-.3409	-.3414	-.3398	-.3425	-.3383	-.3432
-.3441	-.3477	-.3454	-.3386	-.3374	-.3508	-.3391	-.3458
-.3136	-.3257	-.3072	-.2961	-.2883	-.3089	-.2679	-.2564
-.2646	-.2609	-.2482	-.2710	-.2245	-.2316	-.2175	-.2373
-.2302	-.2206	-.2475	-.2067	-.2186	-.2087	-.2242	-.2014
-.2119	-.1985	-.2060	-.2050	-.2002	-.2049	-.1985	-.1868
-.1898	-.1857	-.1750	-.1917	-.1885	-.1855	-.1805	-.1827
-.1970	-.1754	-.1835	-.1856	-.1692	-.1701	-.1684	-.1674
-.1678	-.1676	-.1613	-.1542	-.1657	-.1655	-.1634	-.1575
-.1602	-.1595	-.1619	-.1599	-.1645	-.1676	-.1622	-.1684
-.1657	-.1590	-.1678	-.1711	-.1719	-.1695	-.1775	-.1710
-.1786	-.1778	-.1815	-.1894	-.1932	-.1961	-.2059	-.1997
-.2139	-.2160	-.2237	-.2262	-.2268	-.2240	-.2321	-.2391
-.2403	-.2519	-.2534	-.2572	-.2592	-.2615	-.2643	-.2701
-.2715	-.2802	-.2779	-.2821	-.2840	-.2905	-.2865	-.2892
-.2921	-.2926	-.2911	-.2990	-.2910	-.3002	-.2940	-.3026
-.2886	-.3003	-.3017	-.2968	-.2935	-.3003	-.2904	-.2921
-.2846	-.2913	-.2849	-.2864	-.2786	-.2804	-.2877	-.2476
-.2769	-.2839	-.2654	-.2684	-.2632	-.2502	-.2691	-.2476
-.2460	-.2672	-.2591	-.2476	-.2517	-.2374	-.2160	-.2312
-.2228	-.2055	-.2167	-.2270	-.2238	-.2156	-.1992	-.2201
-.1984	-.2088	-.2005	-.2044	-.2216	-.2095	-.1929	-.1932
-.1832	-.1860	-.1921	-.1904	-.1913	-.1888	-.1937	-.1864
-.1949	-.1766	-.1766	-.1739	-.1801	-.1727	-.1728	-.1702
-.1688	-.1692	-.1586	-.1613	-.1564	-.1637	-.1605	-.1659
-.1686	-.1609	-.1601	-.1543	-.1590	-.1561	-.1643	-.1596
-.1565	-.1695	-.1561	-.1634	-.1614	-.1680	-.1640	-.1715

AVERAGE UNSTEADY WALL PRESSURE DATA -- FILE - W54504

-.1680	-.1804	-.1868	-.1997	-.2043	-.2102	-.2282	-.2271
-.2363	-.2445	-.2451	-.2529	-.2637	-.2746	-.2763	-.2850
-.2876	-.2941	-.2959	-.3006	-.3115	-.3188	-.3191	-.3272
-.3275	-.3357	-.3412	-.3456	-.3484	-.3499	-.3562	-.3578
-.3644	-.3689	-.3690	-.3666	-.3714	-.3788	-.3821	-.3845
-.3819	-.3842	-.3782	-.3890	-.3721	-.3846	-.3888	-.3875
-.3734	-.3776	-.3397	-.3626	-.3593	-.3260	-.3582	-.2981
-.3375	-.2762	-.2280	-.2355	-.2591	-.2356	-.2447	-.2233
-.2327	-.2102	-.2109	-.2009	-.1928	-.2108	-.1959	-.1945
-.2116	-.1974	-.1993	-.2122	-.2019	-.2202	-.1948	-.1977
-.1975	-.1901	-.1706	-.1683	-.1559	-.1528	-.1412	-.1388
-.1497	-.1490	-.1435	-.1259	-.1328	-.1304	-.1461	-.1330
-.1320	-.1356	-.1396	-.1453	-.1280	-.1318	-.1234	-.1253
-.1203	-.1245	-.1177	-.1225	-.1134	-.1169	-.1179	-.1066
-.1130	-.0996	-.1181	-.1151	-.1139	-.1173	-.1236	-.1263
-.1292	-.1285	-.1374	-.1544	-.1565	-.1612	-.1682	-.1567
-.1741	-.1901	-.1948	-.2041	-.2074	-.2212	-.2207	-.2320
-.2382	-.2465	-.2502	-.2546	-.2561	-.2646	-.2704	-.2749
-.2806	-.2816	-.2872	-.2949	-.2921	-.3020	-.2995	-.3033
-.3076	-.3076	-.3144	-.3069	-.3138	-.3218	-.3164	-.3226
-.3266	-.3182	-.3173	-.3264	-.3219	-.3308	-.3171	-.3325
-.3147	-.3269	-.3088	-.3139	-.3073	-.3108	-.3018	-.2916
-.3144	-.2809	-.2523	-.3038	-.2858	-.2911	-.2751	-.2605
-.2476	-.2556	-.2283	-.2398	-.2159	-.2331	-.2196	-.2302
-.2200	-.2328	-.2212	-.2339	-.2168	-.2182	-.2235	-.2169
-.2157	-.2063	-.2126	-.2172	-.2217	-.2117	-.1979	-.2065
-.1962	-.1881	-.1746	-.1648	-.1613	-.1464	-.1396	-.1331
-.1332	-.1327	-.1396	-.1421	-.1378	-.1428	-.1392	-.1358
-.1441	-.1344	-.1435	-.1321	-.1405	-.1309	-.1276	-.1311
-.1312	-.1202	-.1115	-.1122	-.1135	-.1147	-.1185	-.1163
-.1148	-.1214	-.1104	-.1081	-.1126	-.1141	-.1180	-.1159
-.1269	-.1311	-.1319	-.1282	-.1370	-.1433	-.1432	-.1502

AVERAGE UNSTEADY WALL PRESSURE DATA -- FILE - W54505

-.1406	-.1842	-.1820	-.1926	-.2051	-.2366	-.2288	-.2376
-.2493	-.2598	-.2760	-.2841	-.2987	-.3092	-.3161	-.3156
-.3168	-.3306	-.3407	-.3505	-.3612	-.3596	-.3665	-.3733
-.3796	-.3783	-.3845	-.3849	-.3946	-.3925	-.3949	-.3964
-.3966	-.3963	-.3967	-.4014	-.3951	-.3969	-.3989	-.3936
-.3918	-.3869	-.3936	-.3924	-.3830	-.3701	-.3802	-.3731
-.3461	-.3672	-.3536	-.3370	-.3368	-.3157	-.3304	-.2782
-.2966	-.2434	-.2544	-.2420	-.2482	-.2225	-.2680	-.2010
-.1849	-.1804	-.2012	-.1874	-.1643	-.1702	-.1590	-.1477
-.1686	-.1421	-.1469	-.1520	-.1513	-.1580	-.1605	-.1585
-.1438	-.1482	-.1593	-.1566	-.1491	-.1434	-.1450	-.1324
-.1305	-.1251	-.1298	-.1309	-.1250	-.1176	-.1228	-.1171
-.1180	-.0963	-.1067	-.0965	-.0821	-.0891	-.0829	-.0974
-.0781	-.0725	-.0736	-.0706	-.0572	-.0652	-.0632	-.0520
-.0644	-.0613	-.0499	-.0549	-.0572	-.0495	-.0724	-.0830
-.0740	-.0831	-.0976	-.1108	-.1160	-.1316	-.1354	-.1607
-.1644	-.1910	-.1903	-.2106	-.2153	-.2247	-.2438	-.2475
-.2560	-.2660	-.2744	-.2811	-.2925	-.2974	-.2987	-.2925
-.3114	-.3196	-.3196	-.3268	-.3268	-.3363	-.3336	-.3410
-.3379	-.3317	-.3357	-.3285	-.3311	-.3257	-.3334	-.3340
-.3306	-.3263	-.3302	-.3226	-.3239	-.3237	-.3228	-.3283
-.3222	-.3091	-.3163	-.3310	-.3024	-.3170	-.2825	-.2922
-.3142	-.2971	-.2894	-.2718	-.2885	-.2677	-.2713	-.2665
-.2421	-.2238	-.2472	-.2343	-.2220	-.2232	-.2254	-.2182
-.2200	-.2174	-.2400	-.1959	-.2091	-.1997	-.2221	-.1976
-.1857	-.1765	-.1883	-.1818	-.1644	-.1683	-.1761	-.1650
-.1620	-.1556	-.1549	-.1498	-.1561	-.1507	-.1451	-.1472
-.1339	-.1374	-.1433	-.1392	-.1157	-.1259	-.1141	-.1125
-.1177	-.1083	-.0973	-.0961	-.1037	-.0977	-.0893	-.0862
-.0871	-.0815	-.0720	-.0755	-.0729	-.0686	-.0678	-.0588
-.0587	-.0541	-.0640	-.0502	-.0636	-.0553	-.0574	-.0646
-.0729	-.0704	-.0686	-.0793	-.0845	-.0975	-.1168	-.1340

AVERAGE UNSTEADY WALL PRESSURE DATA -- FILE - W54506

-.2598	-.2636	-.2987	-.3012	-.3183	-.3355	-.3432	-.3467
-.3666	-.3819	-.3956	-.3908	-.3990	-.4218	-.4269	-.4268
-.4354	-.4381	-.4453	-.4508	-.4560	-.4534	-.4622	-.4652
-.4693	-.4757	-.4736	-.4765	-.4797	-.4749	-.4792	-.4709
-.4733	-.4739	-.4643	-.4662	-.4720	-.4628	-.4560	-.4670
-.4488	-.4466	-.4650	-.4269	-.4273	-.4198	-.4256	-.4104
-.3380	-.4071	-.3317	-.3011	-.3208	-.2444	-.2754	-.2357
-.2467	-.2852	-.2320	-.1887	-.2039	-.2221	-.1791	-.2054
-.1630	-.1721	-.1421	-.1721	-.1514	-.1560	-.1572	-.1506
-.1616	-.1760	-.1484	-.1620	-.1539	-.1517	-.1361	-.1579
-.1464	-.1413	-.1447	-.1315	-.1240	-.1210	-.1191	-.1119
-.0992	-.0987	-.1071	-.1007	-.0984	-.0830	-.0866	-.0836
-.0908	-.0736	-.0716	-.0477	-.0474	-.0600	-.0302	-.0254
-.0095	-.0134	-.0047	0.0027	0.0167	0.0236	0.0461	0.0421
0.0436	0.0384	0.0525	0.0247	0.0197	-.0093	-.0390	-.0406
-.0592	-.0843	-.1388	-.1405	-.1602	-.1988	-.2042	-.2460
-.2667	-.2864	-.2922	-.3111	-.3118	-.3258	-.3428	-.3482
-.3521	-.3573	-.3619	-.3693	-.3736	-.3767	-.3820	-.3846
-.3841	-.3888	-.3943	-.3882	-.3917	-.3853	-.3935	-.3892
-.3881	-.3878	-.3836	-.4033	-.4004	-.3935	-.3900	-.3918
-.3937	-.3791	-.3905	-.3922	-.3838	-.3725	-.3740	-.3711
-.3595	-.3599	-.3165	-.3395	-.3131	-.3670	-.2952	-.2954
-.3120	-.2677	-.2801	-.2694	-.2728	-.2718	-.2478	-.2626
-.2552	-.2547	-.2512	-.2499	-.2242	-.2481	-.2701	-.2506
-.2130	-.2367	-.2176	-.1892	-.2212	-.1999	-.1742	-.1769
-.1769	-.1798	-.1685	-.1489	-.1546	-.1542	-.1403	-.1425
-.1524	-.1431	-.1330	-.1185	-.1338	-.1207	-.1276	-.1211
-.1144	-.1025	-.1112	-.1083	-.1054	-.0920	-.1076	-.0930
-.0822	-.0763	-.0756	-.0685	-.0709	-.0622	-.0517	-.0497
-.0291	-.0236	-.0117	0.0020	0.0062	0.0157	0.0260	0.0342
0.0394	0.0433	0.0577	0.0394	0.0497	0.0207	0.0228	0.0125
-.0147	-.0302	-.0758	-.0980	-.1176	-.1286	-.1300	-.1789

AVERAGE UNSTEADY WALL PRESSURE DATA -- FILE - W54507

-.0974	-.1354	-.1413	-.1634	-.2119	-.2103	-.2476	-.2553
-.2884	-.3123	-.3575	-.3545	-.3851	-.4119	-.4333	-.4434
-.4416	-.4555	-.4724	-.4822	-.4916	-.5015	-.5028	-.5031
-.5034	-.5013	-.4972	-.4898	-.5015	-.5088	-.4977	-.4744
-.4837	-.4550	-.4646	-.4615	-.4532	-.4232	-.4481	-.4298
-.3857	-.4068	-.3842	-.3748	-.2885	-.3635	-.2496	-.3130
-.2863	-.2837	-.2550	-.2607	-.2231	-.2237	-.2348	-.2112
-.1877	-.2177	-.1988	-.1993	-.1790	-.1947	-.1769	-.1922
-.1672	-.1815	-.2004	-.1476	-.1742	-.1508	-.1485	-.1490
-.1377	-.1497	-.1494	-.1502	-.1508	-.1367	-.1272	-.1394
-.1351	-.1300	-.1106	-.1269	-.1205	-.1100	-.1162	-.1113
-.1012	-.1076	-.0989	-.0944	-.1071	-.0876	-.0795	-.0716
-.0602	-.0534	-.0482	-.0304	-.0368	-.0175	-.0268	-.0111
-.0213	0.0011	-.0019	0.0051	0.0136	0.0031	0.0125	0.0090
0.0135	0.0060	-.0017	-.0169	-.0248	-.0281	-.0345	-.0341
-.0458	-.0403	-.0612	-.0731	-.0874	-.0959	-.1259	-.1490
-.1734	-.1730	-.1909	-.2223	-.2439	-.2633	-.2852	-.3013
-.3131	-.3250	-.3588	-.3647	-.3894	-.4027	-.4142	-.4260
-.4331	-.4382	-.4382	-.4443	-.4383	-.4311	-.4352	-.4273
-.4105	-.4187	-.4018	-.4144	-.4044	-.4000	-.3997	-.3495
-.3714	-.3570	-.3492	-.3231	-.3444	-.3492	-.3216	-.3444
-.3359	-.3153	-.3106	-.2953	-.2980	-.3047	-.2960	-.2840
-.2999	-.2832	-.3182	-.2477	-.2522	-.2728	-.2636	-.2389
-.2720	-.2555	-.2233	-.2274	-.2141	-.2019	-.2023	-.2043
-.1885	-.1979	-.2023	-.2061	-.1825	-.1843	-.1577	-.1673
-.1559	-.1642	-.1728	-.1346	-.1314	-.1277	-.1438	-.1323
-.1250	-.1351	-.1199	-.1201	-.1228	-.1160	-.1071	-.1096
-.1009	-.0996	-.1110	-.0922	-.0878	-.0797	-.0746	-.0656
-.0710	-.0606	-.0605	-.0482	-.0459	-.0416	-.0215	-.0283
-.0039	-.0061	0.0056	0.0109	0.0076	0.0208	0.0231	0.0252
0.0350	0.0365	0.0402	0.0322	0.0321	0.0236	0.0189	0.0304
0.0059	0.0207	0.0162	0.0034	-.0128	-.0082	-.0357	-.0478

AVERAGE UNSTEADY WALL PRESSURE DATA -- FILE - W54508

0.0084	0.0036	0.0040	0.0072	-0.0008	0.0006	0.0051	0.0069
0.0128	0.0183	0.0138	0.0113	0.0190	0.0209	0.0192	0.0068
0.0184	0.0027	-0.0071	-0.0143	-0.0260	-0.0363	-0.0580	-0.0856
-0.0948	-0.1321	-0.1738	-0.2119	-0.2356	-0.2667	-0.3071	-0.3184
-0.3394	-0.3636	-0.3622	-0.3623	-0.3591	-0.3752	-0.3794	-0.4310
-0.3696	-0.4606	-0.4388	-0.3539	-0.3483	-0.3610	-0.3641	-0.3269
-0.3435	-0.3640	-0.3255	-0.3230	-0.3498	-0.3192	-0.3245	-0.3242
-0.3037	-0.3050	-0.2978	-0.2908	-0.2748	-0.2749	-0.2756	-0.2680
-0.2599	-0.2566	-0.2264	-0.2240	-0.2198	-0.2189	-0.2138	-0.1926
-0.1962	-0.1901	-0.1795	-0.1719	-0.1664	-0.1507	-0.1532	-0.1533
-0.1419	-0.1273	-0.1218	-0.1142	-0.1211	-0.1116	-0.1073	-0.1003
-0.0946	-0.0843	-0.0858	-0.0800	-0.0693	-0.0621	-0.0620	-0.0673
-0.0634	-0.0494	-0.0571	-0.0517	-0.0531	-0.0389	-0.0373	-0.0362
-0.0321	-0.0321	-0.0278	-0.0375	-0.0314	-0.0328	-0.0310	-0.0393
-0.0198	-0.0331	-0.0254	-0.0342	-0.0292	-0.0255	-0.0301	-0.0292
-0.0279	-0.0317	-0.0245	-0.0290	-0.0269	-0.0357	-0.0262	-0.0298
-0.0245	-0.0341	-0.0274	-0.0249	-0.0199	-0.0253	-0.0135	-0.0217
-0.0056	0.0009	-0.0050	0.0016	-0.0006	-0.0037	0.0023	0.0112
0.0077	0.0076	0.0095	-0.0075	-0.0075	-0.0279	-0.0469	-0.0682
-0.0802	-0.1227	-0.1378	-0.1859	-0.2207	-0.2441	-0.2606	-0.2657
-0.3128	-0.3111	-0.3307	-0.3325	-0.3723	-0.3924	-0.4076	-0.4238
-0.4011	-0.4142	-0.4197	-0.4310	-0.4286	-0.4004	-0.3862	-0.4157
-0.3825	-0.3838	-0.3664	-0.3780	-0.3620	-0.3564	-0.3693	-0.3317
-0.3333	-0.3227	-0.3416	-0.2821	-0.2877	-0.2651	-0.2568	-0.2605
-0.2562	-0.2318	-0.2310	-0.2215	-0.2199	-0.1977	-0.1972	-0.1865
-0.1813	-0.1775	-0.1766	-0.1690	-0.1528	-0.1628	-0.1484	-0.1480
-0.1283	-0.1371	-0.1247	-0.1172	-0.1155	-0.1009	-0.1057	-0.0910
-0.0836	-0.0813	-0.0747	-0.0790	-0.0724	-0.0701	-0.0622	-0.0470
-0.0560	-0.0448	-0.0510	-0.0428	-0.0378	-0.0291	-0.0297	-0.0222
-0.0212	-0.0201	0.0002	-0.0103	-0.0072	0.0031	0.0041	0.0109
0.0078	0.0095	0.0158	0.0151	0.0234	0.0134	0.0113	0.0078
0.0262	0.0203	0.0154	0.0098	0.0155	0.0150	0.0126	0.0134

AVERAGE UNSTEADY WALL PRESSURE DATA -- FILE - W54509

-.0256	-.0210	-.0240	-.0251	-.0228	-.0182	-.0183	-.0183
-.0132	-.0162	-.0253	-.0219	-.0307	-.0234	-.0231	-.0307
-.0248	-.0278	-.0250	-.0248	-.0242	-.0202	-.0186	-.0122
-.0056	-.0095	0.0019	0.0109	0.0140	0.0149	0.0206	0.0236
0.0310	0.0323	0.0398	0.0424	0.0446	0.0472	0.0505	0.0573
0.0485	0.0487	0.0529	0.0367	0.0369	0.0211	0.0078	-.0236
-.0409	-.0548	-.0633	-.0828	-.0956	-.1144	-.1368	-.1560
-.1637	-.1706	-.1921	-.1915	-.2019	-.2061	-.2029	-.2073
-.1911	-.2016	-.2183	-.2075	-.2029	-.1818	-.1749	-.1812
-.1745	-.1810	-.1716	-.1588	-.1622	-.1571	-.1562	-.1509
-.1548	-.1531	-.1679	-.1678	-.1734	-.1720	-.1654	-.1589
-.1703	-.1684	-.1705	-.1636	-.1602	-.1687	-.1631	-.1639
-.1541	-.1476	-.1369	-.1299	-.1301	-.1192	-.1163	-.1193
-.1015	-.0871	-.0895	-.0836	-.0769	-.0703	-.0810	-.0670
-.0724	-.0630	-.0687	-.0604	-.0649	-.0649	-.0617	-.0699
-.0666	-.0719	-.0655	-.0635	-.0542	-.0525	-.0632	-.0487
-.0484	-.0422	-.0424	-.0378	-.0284	-.0253	-.0247	-.0263
-.0255	-.0272	-.0269	-.0237	-.0188	-.0185	-.0332	-.0217
-.0189	-.0202	-.0151	-.0210	-.0098	-.0015	-.0053	0.0041
0.0071	0.0130	0.0182	0.0254	0.0296	0.0351	0.0473	0.0494
0.0555	0.0504	0.0546	0.0542	0.0610	0.0631	0.0595	0.0585
0.0625	0.0599	0.0528	0.0437	0.0308	0.0138	-.0115	-.0250
-.0553	-.0579	-.0867	-.1031	-.0936	-.1431	-.1530	-.1775
-.1849	-.1911	-.1998	-.2165	-.2030	-.2220	-.2244	-.2274
-.2157	-.2150	-.1952	-.2057	-.1834	-.1876	-.1913	-.1817
-.1742	-.1784	-.1703	-.1570	-.1575	-.1490	-.1632	-.1680
-.1681	-.1580	-.1551	-.1633	-.1644	-.1641	-.1703	-.1566
-.1518	-.1506	-.1560	-.1557	-.1503	-.1436	-.1373	-.1405
-.1308	-.1196	-.1333	-.1116	-.1032	-.0950	-.0881	-.0761
-.0763	-.0669	-.0605	-.0508	-.0469	-.0482	-.0507	-.0407
-.0389	-.0338	-.0441	-.0413	-.0342	-.0473	-.0368	-.0328
-.0356	-.0426	-.0416	-.0422	-.0370	-.0322	-.0299	-.0222

AVERAGE UNSTEADY WALL PRESSURE DATA -- FILE - W5451C

-.0607	-.0551	-.0595	-.0522	-.0415	-.0414	-.0332	-.0273
-.0096	-.0158	-.0112	0.0092	0.0118	0.0128	0.0170	0.0187
0.0271	0.0348	0.0291	0.0348	0.0387	0.0318	0.0433	0.0360
0.0414	0.0298	0.0307	0.0348	0.0331	0.0292	0.0293	0.0275
0.0403	0.0429	0.0465	0.0422	0.0523	0.0546	0.0545	0.0525
0.0543	0.0648	0.0690	0.0741	0.0755	0.0793	0.0800	0.0760
0.0750	0.0832	0.0769	0.0661	0.0771	0.0769	0.0723	0.0710
0.0752	0.0701	0.0635	0.0641	0.0623	0.0620	0.0544	0.0635
0.0496	0.0482	0.0402	0.0274	0.0142	0.0019	-.0196	-.0473
-.0610	-.0757	-.0838	-.0925	-.1157	-.1269	-.1314	-.1331
-.1501	-.1505	-.1461	-.1575	-.1548	-.1559	-.1619	-.1385
-.1488	-.1354	-.1335	-.1246	-.1103	-.1099	-.1218	-.1002
-.1085	-.0929	-.0888	-.0879	-.0961	-.0978	-.1016	-.1104
-.0968	-.0987	-.1035	-.0990	-.1017	-.1005	-.0955	-.0950
-.0845	-.0972	-.0801	-.0862	-.0809	-.0816	-.0770	-.0789
-.0684	-.0772	-.0698	-.0707	-.0634	-.0602	-.0546	-.0515
-.0489	-.0504	-.0405	-.0378	-.0333	-.0285	-.0229	-.0227
-.0093	-.0069	0.0050	0.0039	0.0216	0.0195	0.0176	0.0315
0.0322	0.0354	0.0418	0.0485	0.0445	0.0405	0.0535	0.0453
0.0488	0.0484	0.0403	0.0439	0.0482	0.0441	0.0435	0.0456
0.0449	0.0487	0.0458	0.0532	0.0525	0.0563	0.0552	0.0589
0.0581	0.0682	0.0708	0.0706	0.0739	0.0732	0.0763	0.0795
0.0782	0.0826	0.0892	0.0872	0.0763	0.0711	0.0842	0.0769
0.0683	0.0703	0.0622	0.0568	0.0636	0.0606	0.0551	0.0587
0.0525	0.0486	0.0358	0.0328	0.0251	-.0113	-.0230	-.0412
-.0503	-.0622	-.0810	-.0919	-.0991	-.1126	-.1286	-.1258
-.1378	-.1453	-.1413	-.1459	-.1408	-.1392	-.1330	-.1378
-.1311	-.1226	-.1118	-.0979	-.0941	-.0888	-.0918	-.0876
-.0844	-.0805	-.0821	-.0862	-.0637	-.0839	-.0904	-.0799
-.0849	-.0867	-.0828	-.0935	-.0846	-.0845	-.0760	-.0735
-.0731	-.0633	-.0685	-.0624	-.0595	-.0584	-.0400	-.0450
-.0445	-.0445	-.0438	-.0373	-.0271	-.0310	-.0370	-.0346

AVERAGE UNSTEADY WALL PRESSURE DATA -- FILE - W54511

-0.0241	-0.0164	-0.0053	0.0055	C.0083	0.0168	0.0182	C.0324
0.0363	C.0437	0.0416	0.0554	C.0502	0.0463	0.0422	0.0543
0.0421	C.0473	0.0410	0.0558	C.0537	0.0495	0.0459	C.0595
0.0505	C.0533	0.0522	0.0550	C.0568	0.0550	0.0591	C.0639
0.0595	C.0564	0.0637	0.0568	C.0562	0.0559	0.0538	0.0565
0.0562	C.0553	0.0590	0.0538	C.0602	0.0527	0.0526	0.0493
0.0553	C.0578	0.0413	0.0466	C.0438	0.0499	0.0414	0.0482
0.0325	C.0390	0.0444	0.0341	C.0405	0.0407	0.0407	0.0457
0.0448	C.0514	0.0506	0.0578	C.0509	0.0545	0.0529	C.0607
0.0648	C.0624	0.0603	0.0572	C.0596	C.0605	0.0591	0.0616
0.0545	C.0519	0.0505	0.0543	C.0517	0.0467	0.0419	0.0394
0.0352	C.0366	0.0412	C.0400	C.0404	0.0386	0.0380	C.0429
0.0411	C.0431	0.0417	0.0431	C.0420	0.0454	0.0399	C.0409
0.0373	C.0411	0.0425	0.0420	C.0352	0.0389	0.0292	0.0313
0.0178	C.0102	-0.0129	-0.0351	-0.0422	-0.0417	-0.0430	-0.0551
-0.0557	-0.0579	-0.0473	-0.0519	-0.0481	-0.0375	-0.0274	-0.0254
-0.0252	-0.0196	-0.0014	0.0141	C.0125	0.0253	0.0381	C.0384
0.0511	C.0521	0.0585	0.0612	C.0660	0.0569	0.0630	0.0595
0.0650	C.0652	0.0553	0.0528	C.0617	0.0609	0.0585	C.0553
0.0605	C.0607	0.0571	0.0586	C.0634	0.0616	0.0603	C.0588
0.0583	C.0636	0.0594	0.0594	C.0608	0.0648	0.0639	0.0602
0.0643	0.0661	0.0602	0.0616	C.0568	0.0537	0.0627	C.0598
0.0526	C.0548	0.0520	0.0544	C.0520	0.0477	0.0493	0.0455
0.0394	C.0513	0.0449	0.0441	C.0533	0.0509	0.0558	0.0527
0.0590	C.0563	0.0570	0.0556	C.0607	C.0608	0.0638	C.0610
0.0664	C.0635	0.0623	0.0685	C.0664	0.0594	0.0567	0.0611
0.0630	C.0541	0.0544	0.0566	C.0507	0.0491	0.0447	0.0393
0.0475	C.0464	0.0420	0.0497	C.0431	0.0517	0.0452	C.0423
0.0506	C.0421	0.0467	0.0451	C.0461	0.0440	0.0394	0.0393
0.0406	C.0346	0.0311	0.0311	C.0307	0.0380	0.0269	0.0132
0.0149	C.0054	-0.0172	-0.0196	-0.0248	-0.0357	-0.0350	-0.0375
-0.0380	-0.0317	-0.0345	-0.0241	-0.0214	-0.0269	-0.0148	-0.0050

AVERAGE UNSTEADY WALL PRESSURE DATA -- FILE - W54512

0.0439	0.0463	0.0499	0.0542	0.0516	0.0580	0.0644	0.0615
0.0686	0.0673	0.0726	0.0681	0.0705	0.0678	0.0687	0.0704
0.0711	0.0676	0.0772	0.0719	0.0769	0.0755	0.0775	0.0851
0.0801	0.0831	0.0805	0.0846	0.0735	0.0809	0.0815	0.0738
0.0752	0.0748	0.0742	0.0750	0.0644	0.0637	0.0665	0.0669
0.0620	0.0575	0.0542	0.0563	0.0570	0.0532	0.0652	0.0599
0.0643	0.0658	0.0585	0.0666	0.0590	0.0665	0.0681	0.0715
0.0702	0.0718	0.0657	0.0630	0.0597	0.0576	0.0582	0.0577
0.0532	0.0603	0.0426	0.0529	0.0493	0.0465	0.0502	0.0519
0.0481	0.0494	0.0508	0.0519	0.0522	0.0574	0.0636	0.0587
0.0645	0.0590	0.0663	0.0684	0.0693	0.0727	0.0654	0.0659
0.0636	0.0619	0.0604	0.0520	0.0466	0.0502	0.0366	0.0263
0.0283	0.0210	0.0108	0.0042	0.0035	0.0031	0.0019	-0.0012
0.0066	0.0035	0.0049	0.0138	0.0083	0.0167	0.0183	0.0164
0.0136	0.0192	0.0195	0.0248	0.0199	0.0251	0.0310	0.0276
0.0329	0.0245	0.0400	0.0389	0.0438	0.0410	0.0373	0.0414
0.0420	0.0527	0.0550	0.0593	0.0599	0.0643	0.0565	0.0698
0.0613	0.0659	0.0647	0.0637	0.0729	0.0800	0.0637	0.0731
0.0759	0.0699	0.0745	0.0705	0.0764	0.0799	0.0751	0.0780
0.0742	0.0835	0.0832	0.0826	0.0813	0.0812	0.0808	0.0777
0.0812	0.0742	0.0701	0.0728	0.0704	0.0655	0.0641	0.0651
0.0593	0.0618	0.0585	0.0594	0.0515	0.0589	0.0611	0.0584
0.0562	0.0663	0.0538	0.0577	0.0556	0.0590	0.0551	0.0593
0.0551	0.0592	0.0607	0.0649	0.0591	0.0606	0.0579	0.0580
0.0498	0.0560	0.0545	0.0513	0.0531	0.0523	0.0518	0.0457
0.0569	0.0501	0.0468	0.0555	0.0585	0.0588	0.0565	0.0555
0.0605	0.0609	0.0591	0.0616	0.0618	0.0596	0.0619	0.0556
0.0543	0.0546	0.0464	0.0491	0.0501	0.0420	0.0450	0.0284
0.0293	0.0240	0.0084	0.0014	0.0007	0.0082	0.0	0.0049
0.0078	0.0036	0.0172	0.0124	0.0144	0.0144	0.0193	0.0166
0.0203	0.0289	0.0230	0.0211	0.0258	0.0259	0.0340	0.0378
0.0335	0.0340	0.0266	0.0492	0.0427	0.0431	0.0426	0.0446

ARRAY CF PRESSURES

-- FILE - W54501

359.47	358.09	360.05	358.69	358.16	360.21	359.55	359.73
359.65	359.40	357.38	358.69	358.64	357.51	357.66	357.18
356.60	357.71	357.28	354.96	356.22	356.12	356.00	355.75
355.85	357.06	354.66	355.27	353.07	353.55	354.61	353.70
353.15	352.87	352.49	353.70	351.56	352.07	353.00	352.85
351.84	352.67	352.12	352.27	351.23	350.98	350.18	349.37
350.35	349.52	349.50	351.06	350.68	349.02	349.09	348.26
348.44	324.32	347.35	347.63	348.26	347.56	349.24	348.24
347.25	347.03	347.38	347.18	347.33	345.56	348.89	345.44
346.75	344.35	348.92	349.57	345.67	348.03	349.24	345.31
349.24	349.17	351.18	348.51	351.18	353.23	352.97	355.85
352.67	351.46	352.77	353.00	353.63	355.09	354.89	354.08
354.66	355.64	356.25	354.69	356.30	355.42	355.14	354.43
354.13	353.40	353.80	356.50	355.47	354.74	354.51	354.26
353.30	355.64	355.24	355.85	354.03	355.95	356.53	356.70
358.04	357.74	358.95	357.86	357.84	356.02	358.06	357.48
358.04	360.51	356.83	358.39	359.78	360.79	359.78	357.48
359.98	360.94	360.63	359.00	358.69	358.39	358.74	358.84
358.19	357.96	356.58	355.52	357.89	355.67	356.22	356.00
356.75	355.42	355.92	354.94	354.91	356.17	355.24	354.99
353.23	355.09	354.81	353.83	353.78	353.88	355.09	352.85
351.94	354.06	353.68	353.45	353.12	353.98	352.19	353.10
352.77	352.07	352.62	352.47	352.22	350.65	349.85	351.79
350.98	350.55	349.75	349.52	350.48	348.69	348.19	348.66
349.60	349.39	349.12	350.53	348.54	350.71	350.18	350.30
351.36	349.80	348.44	350.88	349.34	350.18	352.39	354.23
353.73	353.63	355.09	351.99	353.23	356.22	355.24	355.32
353.55	358.87	356.25	354.86	356.05	358.16	355.67	356.30
356.68	356.63	356.27	358.77	357.08	356.93	354.71	358.47
355.37	355.59	356.17	356.50	356.00	354.94	354.79	356.22
354.59	356.30	356.25	355.85	355.32	357.26	357.38	357.43
359.45	355.47	358.32	356.75	358.47	359.35	358.74	360.05

ARRAY CF PRESSURES

-- FILE - W54502

361.06	359.45	361.41	359.15	360.55	358.11	358.47	356.38
356.50	355.07	356.23	357.03	354.67	356.18	353.71	350.49
354.47	354.72	353.79	351.72	351.24	351.37	350.46	351.19
348.80	348.83	348.10	347.32	347.32	345.99	344.75	345.08
344.25	344.58	343.34	341.53	342.29	341.33	340.68	340.12
340.60	339.67	339.42	338.66	337.43	336.95	336.65	337.20
337.86	336.63	336.80	335.24	334.51	334.99	335.19	332.73
334.81	335.64	332.50	333.45	337.88	337.53	338.14	337.98
335.47	333.20	340.48	338.51	341.56	341.48	345.51	338.86
345.26	347.80	342.56	349.61	346.59	348.63	346.54	351.24
349.23	351.87	349.86	356.13	349.53	352.30	350.92	353.08
353.76	351.95	349.94	354.04	356.08	359.60	356.55	359.75
355.22	362.74	363.05	361.35	362.17	359.60	361.01	363.32
362.92	359.85	363.52	361.56	360.50	360.55	362.32	360.91
360.53	359.80	360.15	361.33	363.20	360.50	361.91	361.11
361.33	362.22	360.91	363.22	362.42	362.37	360.25	358.99
360.18	360.50	358.32	360.35	357.66	357.74	359.32	357.41
357.11	355.72	356.15	356.63	356.20	355.12	355.04	353.64
354.01	353.71	353.03	352.25	352.63	352.02	350.54	349.84
350.11	349.79	349.58	349.23	348.53	349.28	346.41	346.84
346.61	345.68	344.78	344.53	344.58	344.12	344.43	345.16
343.29	343.09	342.16	343.65	342.06	342.16	342.24	341.86
340.85	341.66	342.89	342.06	341.86	340.53	342.59	342.04
340.55	341.15	342.24	342.56	339.57	342.36	344.60	347.04
345.76	342.84	348.28	346.46	347.97	347.90	349.71	351.40
350.09	349.46	351.97	349.73	351.04	350.84	351.67	351.07
350.04	350.19	350.54	353.41	350.92	356.03	355.14	352.45
352.33	355.50	360.15	354.09	355.75	358.54	361.08	357.01
361.59	358.59	360.10	359.35	361.49	363.52	361.08	364.33
363.45	361.86	360.86	360.15	363.42	359.80	360.91	361.79
362.64	362.32	360.81	361.03	361.84	362.19	362.04	361.36
360.96	360.38	362.67	361.35	363.62	361.74	360.66	362.22

ARRAY OF PRESSURES

-- FILE - W54503

358.96	359.40	357.10	358.03	353.67	356.12	352.30	352.54
350.63	348.23	349.95	348.43	345.76	344.51	344.33	343.13
340.61	339.85	339.21	338.87	337.45	336.57	334.29	331.89
333.65	331.77	330.64	329.93	329.66	329.10	327.14	325.57
325.74	325.74	323.49	323.80	321.97	322.63	322.06	321.84
321.23	319.93	319.15	319.03	319.42	318.76	319.79	318.59
318.36	317.48	318.05	319.71	320.01	316.72	319.59	317.95
325.84	322.87	327.41	330.12	332.04	326.99	337.03	339.85
337.84	338.75	341.86	336.27	347.67	345.93	349.38	344.53
346.27	348.62	342.03	352.03	349.11	351.54	347.74	353.33
350.75	354.04	352.20	352.44	353.62	352.47	354.04	356.90
356.17	357.17	359.79	355.70	356.49	357.22	358.45	357.91
354.40	359.70	357.71	357.20	361.22	360.99	361.41	361.66
361.56	361.61	363.15	364.89	362.07	362.12	362.64	364.08
363.42	363.59	363.00	363.49	362.37	361.61	362.93	361.41
362.07	363.71	361.56	360.75	360.55	361.14	359.18	360.77
358.91	359.11	358.20	356.27	355.34	354.62	352.22	353.74
350.26	349.75	347.86	347.25	347.10	347.79	345.80	344.09
343.80	340.95	340.59	339.66	339.17	338.60	337.92	336.49
336.15	334.02	334.58	333.55	333.09	331.50	332.48	331.82
331.10	330.98	331.35	329.41	331.37	329.12	330.64	328.53
331.96	329.10	328.75	329.95	330.76	329.10	331.52	331.10
332.94	331.30	332.87	332.50	334.41	333.97	332.18	342.01
334.83	333.11	337.65	336.91	338.19	341.37	336.74	342.01
342.40	337.21	339.19	342.01	341.00	344.51	349.75	346.03
348.08	352.32	349.58	347.05	347.84	349.85	353.87	348.74
354.06	351.51	353.55	352.59	348.38	351.34	355.41	355.34
357.79	357.10	355.60	356.02	355.80	356.41	355.21	357.00
354.92	359.40	359.40	360.06	358.54	360.36	360.33	360.97
361.31	361.22	363.81	363.15	364.35	362.56	363.35	362.02
361.36	363.25	363.44	364.87	363.71	364.42	362.42	363.57
364.33	361.14	364.42	362.64	363.13	361.51	362.49	360.65

ARRAY OF PRESSURES

-- FILE - W54504

358.07	354.97	353.36	350.13	348.98	347.50	342.99	343.26
340.96	338.90	338.75	336.80	334.09	331.36	330.93	328.75
328.10	326.47	326.02	324.84	322.11	320.28	320.20	318.17
318.10	316.04	314.67	313.56	312.86	312.49	310.91	310.51
308.85	307.72	307.70	308.30	307.10	305.24	304.42	303.81
304.47	303.89	305.39	302.69	306.92	303.79	302.74	303.06
306.60	305.54	315.04	309.30	310.13	318.48	310.41	325.47
315.59	330.96	343.04	341.16	335.24	341.13	338.85	344.21
341.86	347.50	347.32	349.83	351.86	347.35	351.08	351.43
347.15	350.71	350.23	347.00	349.58	344.99	351.36	350.63
350.68	352.54	357.42	358.00	361.11	361.88	364.79	365.39
362.66	362.84	364.21	368.63	366.90	367.50	363.56	366.85
367.10	366.19	365.19	363.76	368.10	367.15	369.25	368.78
370.03	368.98	370.68	369.48	371.76	370.88	370.63	373.46
371.86	375.22	370.58	371.33	371.63	370.78	369.20	368.53
367.80	367.97	365.74	361.48	360.96	359.78	358.02	360.91
356.55	352.54	351.36	349.03	348.20	344.74	344.87	342.03
340.48	338.40	337.47	336.37	335.99	333.86	332.41	331.28
329.85	329.60	328.20	326.27	326.97	324.49	325.12	324.16
323.09	323.09	321.38	323.26	321.53	319.53	320.88	319.33
318.33	320.43	320.66	318.38	319.50	317.27	320.71	316.85
321.31	318.25	322.79	321.51	323.16	322.28	324.54	327.10
321.38	329.78	336.95	324.04	328.55	327.22	331.23	334.89
338.12	336.12	342.96	340.08	346.07	341.76	345.14	342.49
345.04	341.83	344.74	341.56	345.84	345.49	344.16	345.82
346.12	348.48	346.90	345.74	344.62	347.12	350.58	348.43
351.01	353.04	356.42	358.88	359.75	363.49	365.19	366.82
366.80	366.92	365.19	364.57	365.64	364.39	365.29	366.14
364.06	366.50	364.21	367.07	364.97	367.37	368.20	367.32
367.30	370.05	372.23	372.06	371.73	371.43	370.48	371.03
371.41	369.75	372.51	373.09	371.96	371.58	370.61	371.13
368.37	367.32	367.12	368.05	365.84	364.26	364.29	362.54

ARRAY OF PRESSURES

-- FILE - W54505

373.26	362.24	362.79	360.11	356.95	348.99	350.96	348.74
345.78	343.13	339.03	336.99	333.30	330.64	328.90	329.02
328.72	325.23	322.68	320.20	317.50	317.90	316.16	314.44
312.85	313.18	311.61	311.51	309.06	309.59	308.98	308.60
308.55	308.63	308.53	307.34	308.93	308.48	307.97	309.31
309.76	311.00	309.31	309.61	311.99	315.25	312.70	314.49
321.32	315.98	319.42	323.62	323.67	329.00	325.28	338.48
333.83	347.27	344.49	347.63	346.06	352.56	341.06	357.99
362.06	363.20	357.94	361.43	367.27	365.77	368.60	371.46
366.18	372.88	371.66	370.37	370.55	368.86	368.23	368.73
372.45	371.33	368.53	369.21	371.11	372.55	372.14	375.33
375.81	377.17	375.99	375.71	377.20	379.07	377.75	379.20
378.97	384.45	381.82	384.40	388.04	386.27	387.84	384.17
389.05	390.47	390.19	390.95	394.33	392.31	392.82	395.65
392.52	393.30	396.18	394.92	394.33	396.28	390.49	387.81
390.09	387.79	384.12	380.79	379.47	375.53	374.57	368.18
367.24	360.52	360.69	355.56	354.37	352.00	347.17	346.24
344.09	341.56	339.44	337.74	334.86	333.62	333.30	334.86
330.09	328.01	328.01	326.19	326.19	323.79	324.47	322.60
323.39	324.96	323.94	325.76	325.11	326.47	324.53	324.37
325.23	326.32	325.33	327.25	326.93	326.98	327.20	325.81
327.36	330.67	328.85	325.13	332.36	328.67	337.39	334.94
329.38	333.70	335.65	340.09	335.87	341.13	340.22	341.43
347.60	352.23	346.31	349.57	352.68	352.38	351.82	353.64
353.19	353.84	348.13	359.28	355.94	358.32	352.66	358.85
361.86	364.18	361.20	362.84	367.24	366.25	364.28	367.09
367.85	369.46	369.64	370.93	369.34	370.70	372.12	371.59
374.95	374.06	372.57	373.61	379.55	376.97	379.95	380.36
379.04	381.42	384.20	384.50	382.58	384.10	386.22	387.01
386.78	388.19	390.59	389.71	390.37	391.45	391.66	393.93
393.96	395.12	392.62	396.10	392.72	394.81	394.28	392.46
390.37	391.00	391.45	388.75	387.43	384.15	379.27	374.92

ARRAY OF PRESSURES

-- FILE - W54506

343.14	342.20	333.51	332.90	328.66	324.41	322.50	321.63
316.71	312.92	309.53	310.72	308.69	303.05	301.78	301.81
299.68	299.01	297.23	295.87	294.58	295.23	293.05	292.31
291.29	289.71	290.23	289.51	288.72	289.90	288.84	290.89
290.30	290.15	292.53	292.06	290.62	292.90	294.58	291.86
296.36	296.91	292.35	301.78	301.69	303.54	302.11	305.87
323.79	306.69	325.35	332.92	328.04	346.95	339.28	349.11
346.38	336.86	350.02	360.74	356.98	352.47	363.11	356.61
367.10	364.85	372.27	364.85	369.97	368.83	368.54	370.17
367.45	363.88	370.71	367.35	369.35	369.90	373.76	368.36
371.21	372.47	371.63	374.90	376.75	377.49	377.97	379.75
382.89	383.01	380.94	382.52	383.09	386.90	386.01	386.75
384.97	389.23	389.72	395.64	395.71	392.59	399.97	401.16
405.09	404.13	406.28	408.11	411.58	413.28	418.85	417.86
418.23	416.95	420.44	413.56	412.32	405.14	397.79	397.39
392.79	386.58	373.09	372.67	367.79	358.24	356.90	346.56
341.43	336.56	335.12	330.45	330.27	326.81	322.60	321.26
320.30	319.01	317.87	316.04	314.98	314.21	312.90	312.25
312.38	311.21	309.85	311.36	310.50	312.08	310.05	311.12
311.39	311.46	312.50	307.63	308.34	310.05	310.92	310.47
310.00	313.61	310.79	310.37	312.45	315.25	314.88	315.59
318.47	318.37	329.11	323.42	329.95	316.61	334.38	334.33
330.22	341.19	338.12	340.77	339.92	340.17	346.11	342.45
344.28	344.40	345.27	345.59	351.95	346.04	340.59	345.42
354.72	348.86	353.59	360.62	352.70	357.97	364.33	363.66
363.66	362.94	365.74	370.59	369.18	369.28	372.72	372.17
369.72	372.03	374.52	378.11	374.33	377.57	375.86	377.47
379.13	382.07	379.92	380.64	381.36	384.67	380.81	384.42
387.10	388.56	388.73	390.49	389.89	392.05	394.65	395.14
400.24	401.60	404.55	407.94	408.98	411.33	413.88	415.91
417.19	418.16	421.72	417.19	419.74	412.57	413.09	410.54
403.80	399.97	388.68	383.19	378.34	375.61	375.27	363.16

ARRAY OF PRESSURES

-- FILE - W54507

387.95	378.41	376.93	371.38	359.21	359.61	350.24	348.31
340.00	334.01	322.66	323.41	315.73	309.01	303.63	301.10
301.55	298.06	293.82	291.36	289.00	286.52	286.19	286.11
286.04	286.57	287.60	289.45	286.52	284.68	287.47	293.32
290.98	298.19	295.78	296.56	298.64	306.17	299.92	304.51
315.58	310.29	315.96	318.32	339.98	321.15	349.74	333.83
340.53	341.18	348.39	346.56	356.39	356.24	353.46	359.38
365.28	357.75	362.49	362.37	367.46	363.52	367.99	364.15
370.43	366.84	362.09	375.34	368.67	374.54	375.12	374.59
377.83	374.82	374.89	374.69	374.54	378.08	380.47	377.40
378.48	379.76	384.63	380.54	382.15	384.78	383.23	384.46
386.99	385.39	387.57	388.70	385.51	390.40	392.44	394.42
397.28	398.99	400.29	404.76	403.16	408.00	405.67	409.61
407.05	412.67	411.92	413.67	415.81	413.17	415.53	414.65
415.78	413.90	411.97	408.15	406.17	405.34	403.73	403.83
400.90	402.28	397.03	394.04	390.46	388.32	380.79	374.99
368.87	368.97	364.48	356.60	351.17	346.30	340.81	336.77
333.80	330.82	322.33	320.85	314.65	311.31	308.43	305.47
303.68	302.40	302.40	300.87	302.38	304.19	303.16	305.14
309.36	307.30	311.54	308.38	310.89	311.99	312.07	324.67
319.17	322.79	324.74	331.29	325.95	324.74	331.67	325.95
328.08	333.25	334.43	338.27	337.59	335.91	338.10	341.11
337.12	341.31	332.52	350.22	349.09	343.92	346.23	352.43
344.12	348.26	356.34	355.32	358.65	361.72	361.62	361.11
365.08	362.72	361.62	360.66	366.58	366.13	372.81	370.40
373.26	371.18	369.02	378.61	379.41	380.34	376.30	379.19
381.02	378.48	382.30	382.25	381.57	383.28	385.51	384.88
387.07	387.39	384.53	389.25	390.35	392.39	393.67	395.93
394.57	397.18	397.21	400.29	400.87	401.95	407.00	405.29
411.41	410.86	413.80	415.13	414.30	417.61	418.19	418.72
421.18	421.55	422.48	420.47	420.45	418.32	417.14	420.02
413.87	417.59	416.46	413.25	409.18	410.33	403.43	400.39

ARRAY OF PRESSURES

-- FILE - W54508

405.01	403.81	403.91	404.71	402.71	403.06	404.18	404.63
406.10	407.48	406.35	405.73	407.65	408.13	407.70	404.61
407.50	403.58	401.14	399.34	396.42	393.85	388.43	381.54
379.25	369.93	359.52	350.01	344.10	336.33	326.25	323.43
318.19	312.15	312.50	312.47	313.27	309.25	308.20	295.32
310.65	287.93	293.37	314.57	315.97	312.79	312.02	321.31
317.16	312.05	321.66	322.28	315.59	323.23	321.91	321.98
327.10	326.77	328.57	330.32	334.31	334.29	334.11	336.01
338.03	338.86	346.39	346.99	348.04	348.27	349.54	354.83
353.93	355.46	358.10	360.00	361.37	365.29	364.67	364.64
367.49	371.13	372.51	374.40	372.68	375.05	376.12	377.87
379.30	381.87	381.49	382.94	385.61	387.41	387.43	386.11
387.08	390.58	388.66	390.00	389.65	393.20	393.60	393.87
394.90	394.90	395.97	393.55	395.07	394.72	395.17	393.10
397.97	394.65	396.57	394.37	395.62	396.54	395.40	395.62
395.95	395.00	396.79	395.67	396.19	394.00	396.37	395.47
396.79	394.40	396.07	396.69	397.94	396.59	399.54	397.49
401.51	403.13	401.66	403.31	402.76	401.99	403.48	405.71
404.83	404.81	405.28	401.04	401.04	395.95	391.20	385.89
382.89	372.28	368.51	356.50	347.82	341.98	337.86	336.58
324.83	325.25	320.36	319.91	309.97	304.96	301.16	297.12
302.78	299.51	298.14	295.32	295.92	302.96	306.50	299.14
307.43	307.10	311.45	308.55	312.55	313.94	310.72	320.11
319.71	322.36	317.64	332.49	331.09	336.73	338.81	337.88
338.96	345.05	345.25	347.62	348.02	353.56	353.68	356.35
357.65	358.60	358.83	360.72	364.77	362.27	365.87	365.97
370.88	368.69	371.78	373.65	374.08	377.72	376.52	380.19
382.04	382.61	384.26	383.19	384.84	385.41	387.38	391.18
388.93	391.73	390.18	392.23	393.47	395.65	395.50	397.37
397.62	397.89	402.96	400.34	401.11	403.68	403.93	405.63
404.86	405.28	406.85	406.68	408.75	406.25	405.73	404.86
409.45	407.98	406.75	405.36	406.78	406.65	406.05	406.25

ARRAY OF PRESSURES

-- FILE - W54509

402.31	400.95	402.71	402.43	403.01	404.17	404.14	404.14
405.42	404.67	402.38	403.24	401.03	402.86	402.94	401.03
402.51	401.76	402.46	402.51	402.66	403.66	404.07	405.67
407.33	406.35	409.21	411.47	412.25	412.47	413.91	414.66
416.52	416.84	418.72	419.38	419.93	420.58	421.41	423.12
420.91	420.96	422.01	417.95	418.00	414.03	410.69	402.81
398.47	394.98	392.85	387.95	383.73	380.02	374.40	369.58
367.65	365.91	360.52	360.67	358.06	357.00	357.81	356.70
360.77	358.13	353.94	356.65	357.81	363.10	364.83	363.25
364.94	363.30	365.66	368.88	368.02	369.30	369.53	370.86
369.88	370.31	366.59	366.62	365.21	365.56	367.22	368.85
365.99	366.47	365.94	367.67	368.52	366.39	367.80	367.60
370.06	371.69	374.37	376.13	376.08	378.82	379.54	378.79
383.26	386.87	386.27	387.75	389.43	391.09	388.40	391.92
390.56	392.92	391.49	393.57	392.44	392.44	393.25	391.19
392.02	390.69	392.29	392.80	395.13	395.56	392.87	396.51
396.59	398.14	398.09	399.25	401.61	402.38	402.53	402.13
402.33	401.91	401.98	402.79	404.02	404.09	400.40	403.29
403.99	403.66	404.94	403.46	406.27	408.36	407.40	409.76
410.52	412.00	413.30	415.11	416.16	417.54	420.61	421.13
422.67	421.38	422.44	422.34	424.05	424.57	423.67	423.42
424.42	423.77	421.99	419.70	416.47	412.20	405.85	402.46
394.85	394.20	386.97	382.86	385.24	372.82	370.33	364.18
362.32	360.77	358.58	354.39	357.78	353.01	352.41	351.66
354.59	354.77	359.74	357.10	362.70	361.65	360.72	363.13
365.01	363.96	365.99	369.33	369.20	371.34	367.77	366.57
366.54	369.08	369.80	367.75	367.47	367.55	365.99	369.43
370.63	370.93	369.58	369.65	371.01	372.69	374.27	373.47
375.90	378.71	375.28	380.72	382.83	384.89	386.62	389.63
389.58	391.94	393.55	395.98	396.96	396.64	396.01	398.52
398.97	400.25	397.67	398.37	400.15	396.86	399.50	400.50
399.80	398.04	398.29	398.14	399.45	400.65	401.23	403.16

ARRAY OF PRESSURES

-- FILE - W54510

390.46	391.87	390.76	392.60	395.29	395.32	397.38	398.87
403.32	401.76	402.92	407.05	408.71	408.96	410.02	410.45
412.56	414.50	413.06	414.50	415.48	413.74	416.64	414.80
416.16	413.24	413.47	414.50	414.07	413.09	413.11	412.66
415.88	416.54	417.44	416.36	418.91	419.48	419.46	418.96
419.41	422.05	423.11	424.39	424.75	425.70	425.88	424.87
424.62	426.68	425.10	422.38	425.15	425.10	423.94	423.61
424.67	423.39	421.72	421.88	421.42	421.35	419.43	421.72
418.23	417.87	415.86	412.64	409.31	406.22	400.80	393.83
390.38	386.68	384.64	382.45	376.61	373.79	372.66	372.23
367.95	367.85	368.96	366.09	366.77	366.49	364.98	370.87
368.28	371.65	372.13	374.37	377.97	378.07	375.08	380.51
378.42	382.35	383.38	383.61	381.55	381.12	380.16	377.95
381.37	380.89	379.68	380.82	380.14	380.44	381.70	381.82
384.47	381.27	385.57	384.04	385.37	385.20	386.35	385.88
388.52	386.30	388.17	387.94	389.78	390.58	391.99	392.77
393.43	393.05	395.54	396.22	397.36	398.56	399.97	400.02
403.40	404.00	407.00	406.72	411.18	410.65	410.17	413.67
413.84	414.65	416.26	417.95	416.94	415.93	419.21	417.14
418.02	417.92	415.88	416.79	417.87	416.84	416.69	417.22
417.04	418.00	417.27	419.13	418.96	419.91	419.64	420.57
420.37	422.91	423.56	423.51	424.34	424.17	424.95	425.75
425.43	426.53	428.19	427.69	424.95	423.64	426.94	425.10
422.93	423.44	421.40	420.04	421.75	420.99	419.61	420.52
418.96	417.97	414.75	414.00	412.06	402.89	399.95	395.37
393.08	390.08	385.35	382.60	380.79	377.39	373.36	374.07
371.05	369.16	370.17	369.01	370.29	370.70	372.26	371.05
372.73	374.87	377.59	381.09	382.05	383.38	382.63	383.69
384.49	385.47	385.07	384.04	389.70	384.62	382.98	385.62
384.36	383.91	384.89	382.20	384.44	384.47	386.61	387.23
387.34	389.80	388.49	390.03	390.76	391.04	395.67	394.41
394.54	394.54	394.71	396.35	398.92	397.93	396.42	397.03

ARRAY OF PRESSURES

-- FILE - W54511

393.59	395.25	397.63	399.95	400.55	402.38	402.68	405.73
406.56	408.15	407.70	410.67	409.55	408.71	407.83	410.43
407.81	408.93	407.57	410.75	410.30	409.40	408.63	411.55
409.61	410.22	409.98	410.58	410.97	410.58	411.46	412.49
411.55	410.88	412.45	410.97	410.84	410.77	410.32	410.90
410.84	410.65	411.44	410.32	411.70	410.09	410.07	409.36
410.65	411.18	407.64	408.78	408.18	409.49	407.66	409.12
405.75	407.14	408.30	406.09	407.47	407.51	407.51	408.58
408.39	409.81	409.64	411.18	409.70	410.47	410.13	411.80
412.69	412.17	411.72	411.05	411.57	411.76	411.46	412.00
410.47	409.91	409.61	410.43	409.87	408.80	407.77	407.23
406.33	406.63	407.62	407.36	407.45	407.06	406.93	407.98
407.60	408.03	407.72	408.03	407.79	408.52	407.34	407.55
406.78	407.60	407.90	407.79	406.33	407.12	405.04	405.49
402.59	400.96	396.00	391.23	389.71	389.81	388.46	386.94
386.81	386.34	388.61	387.62	388.44	390.72	392.89	393.31
393.36	394.56	398.47	401.80	401.45	404.20	406.95	407.02
409.74	409.96	411.33	411.91	412.94	410.99	412.30	411.55
412.73	412.77	410.65	410.11	412.02	411.85	411.33	410.65
411.76	411.80	411.03	411.35	412.38	412.00	411.72	411.40
411.29	412.43	411.53	411.53	411.83	412.69	412.49	411.70
412.58	412.96	411.70	412.00	410.97	410.30	412.23	411.61
410.07	410.54	409.94	410.45	409.94	409.01	409.36	408.54
407.23	409.79	408.41	408.24	410.22	409.70	410.75	410.09
411.44	410.86	411.01	410.71	411.80	411.83	412.47	411.87
413.03	412.41	412.15	413.48	413.03	411.53	410.95	411.89
412.30	410.39	410.45	410.92	409.66	409.31	408.37	407.21
408.97	408.73	407.79	409.44	408.03	409.87	408.48	407.85
409.64	407.81	408.80	408.45	408.67	408.22	407.23	407.21
407.49	406.20	405.45	405.45	405.36	406.93	404.55	401.60
401.97	399.93	395.08	394.56	393.44	391.10	391.25	390.72
390.61	391.96	391.36	393.59	394.17	392.99	395.59	397.70

ARRAY CF PRESSURES

-- FILE - W54512

417.51	418.11	419.02	420.11	419.45	421.07	422.68	421.95
423.74	423.42	424.75	423.62	424.22	423.54	423.77	424.20
424.37	423.49	425.92	424.58	425.84	425.49	425.99	427.91
426.65	427.41	426.75	427.78	424.98	426.85	427.00	425.06
425.41	425.31	425.16	425.36	422.68	422.51	423.21	423.31
422.08	420.94	420.11	420.64	420.81	419.86	422.89	421.55
422.66	423.04	421.19	423.24	421.32	423.21	423.62	424.48
424.15	424.55	423.01	422.33	421.50	420.97	421.12	420.99
419.86	421.65	417.18	419.78	418.87	418.16	419.10	419.53
418.57	418.90	419.25	419.53	419.60	420.92	422.48	421.24
422.71	421.32	423.16	423.69	423.92	424.78	422.94	423.06
422.48	422.05	421.67	419.55	418.19	419.10	415.66	413.06
413.57	411.72	409.15	407.48	407.31	407.21	406.90	406.12
408.09	407.31	407.66	409.91	408.52	410.64	411.04	410.56
409.86	411.27	411.35	412.68	411.45	412.76	414.25	413.39
414.73	412.61	416.52	416.24	417.48	416.77	415.84	416.88
417.03	419.73	420.31	421.40	421.55	422.66	420.69	424.05
421.90	423.06	422.76	422.51	424.83	426.62	422.51	424.88
425.59	424.07	425.23	424.22	425.71	426.60	425.39	426.12
425.16	427.51	427.43	427.28	426.95	426.93	426.82	426.04
426.93	425.16	424.12	424.80	424.20	422.96	422.61	422.86
421.40	422.03	421.19	421.42	419.43	421.29	421.85	421.17
420.61	423.16	420.01	420.99	420.46	421.32	420.33	421.40
420.33	421.37	421.75	422.81	421.34	421.72	421.04	421.07
419.00	420.56	420.18	419.38	419.83	419.63	419.50	417.96
420.79	419.07	418.24	420.44	421.19	421.27	420.69	420.44
421.70	421.80	421.34	421.98	422.03	421.47	422.05	420.46
420.13	420.21	418.14	418.82	419.07	417.03	417.78	413.59
413.82	412.48	408.54	406.78	406.60	408.49	406.42	407.66
408.39	407.33	410.77	409.55	410.06	410.06	411.30	410.61
411.55	413.72	412.23	411.75	412.94	412.96	415.01	415.97
414.88	415.01	413.14	418.85	417.20	417.30	417.18	417.68

ARRAY OF PRESSURES EVENED

-- FILE - W54501

359.63	358.22	360.19	358.74	358.40	360.00	359.44	359.39
359.34	358.97	357.27	358.53	358.25	357.38	357.27	356.51
356.39	357.41	356.53	354.64	355.73	355.65	355.44	355.29
355.14	356.23	354.01	354.47	352.50	352.80	353.63	352.84
352.26	352.04	351.58	352.53	350.63	350.99	351.77	351.57
350.72	351.37	350.85	350.91	349.85	349.58	348.82	348.15
349.10	348.23	348.23	349.48	349.10	347.61	347.70	346.71
347.07	325.45	345.87	346.21	347.22	346.55	348.13	347.21
346.07	345.64	346.69	346.31	346.75	345.16	348.55	344.78
346.60	344.70	348.28	349.57	345.76	348.09	348.97	345.91
349.24	349.44	351.05	349.27	351.02	353.13	352.77	355.57
352.78	351.51	352.49	353.10	353.87	355.54	355.05	354.65
354.72	356.35	356.93	355.26	356.89	355.84	355.73	355.32
355.01	354.05	354.78	357.01	355.97	355.32	355.29	354.92
354.02	356.06	355.73	356.39	354.95	356.40	357.06	357.14
358.37	358.18	359.14	358.40	358.29	356.66	358.28	357.63
358.25	360.51	356.98	358.59	359.57	360.48	359.73	357.48
359.69	360.41	360.19	358.76	358.44	358.06	358.37	358.32
357.77	357.54	356.22	355.19	357.36	355.30	355.66	355.38
356.09	354.85	355.29	354.37	354.27	355.48	354.36	354.17
352.56	354.15	353.81	352.94	352.86	352.90	354.02	352.08
351.08	352.96	352.53	352.47	352.02	352.80	351.20	351.98
351.58	351.02	351.65	351.43	351.18	349.64	349.12	350.81
349.94	349.61	349.00	349.19	349.43	348.06	347.83	348.50
349.21	348.74	349.03	350.12	348.48	350.42	350.13	350.41
351.23	349.76	348.79	350.77	349.51	350.24	352.32	353.92
353.36	353.28	354.63	352.13	352.99	356.20	355.23	355.03
353.43	358.53	356.64	354.79	356.02	358.20	356.21	356.37
357.17	356.82	356.66	358.83	357.52	357.59	355.35	359.05
356.18	356.22	356.64	356.87	356.74	355.42	355.40	356.78
355.39	356.90	356.70	356.26	355.97	357.75	357.85	357.83
359.60	355.96	358.75	357.22	358.98	359.59	358.93	360.27

ARRAY OF PRESSURES EVENED

-- FILE - W54502

360.23	358.74	360.70	358.91	359.31	359.20	359.03	358.12
358.14	357.32	356.83	357.90	356.73	356.87	355.76	353.97
355.58	356.27	355.60	353.41	353.83	353.84	353.34	353.56
352.47	353.11	351.51	351.45	350.31	349.92	349.88	349.56
348.88	348.89	348.10	348.05	347.11	346.91	347.08	346.74
346.44	346.43	346.02	345.74	344.61	344.25	343.68	343.53
344.35	343.33	343.40	343.47	343.11	342.28	342.42	340.80
341.90	329.76	340.22	340.83	343.28	342.74	343.91	343.31
341.60	340.39	344.06	343.02	344.56	343.60	347.27	342.28
346.03	346.01	345.87	349.59	346.11	348.32	347.95	348.16
349.24	350.47	350.55	352.17	350.39	352.78	351.99	354.52
353.19	351.70	351.41	353.50	354.80	357.25	355.69	356.80
354.93	359.05	359.51	357.90	359.11	357.42	357.96	358.70
358.35	356.50	358.47	358.93	357.89	357.53	358.26	357.45
356.77	357.64	357.60	358.48	358.43	358.13	359.11	358.82
359.62	359.89	359.89	360.43	360.03	359.07	359.11	358.21
359.06	360.51	357.54	359.33	358.76	359.32	359.56	357.45
358.60	358.43	358.48	357.86	357.50	356.82	356.97	356.34
356.18	355.92	354.87	353.95	355.36	353.92	353.50	353.04
353.57	352.71	352.88	352.20	351.85	352.87	351.00	351.08
350.05	350.57	350.00	349.56	349.36	349.20	349.97	349.16
347.79	348.79	348.15	348.74	347.81	348.31	347.41	347.70
347.05	347.07	347.95	347.47	347.25	345.79	346.36	347.11
345.98	346.04	346.14	346.39	345.44	345.65	346.47	347.89
347.75	346.25	348.71	348.58	348.27	349.36	349.95	350.83
350.75	349.63	350.13	350.33	350.16	350.50	352.05	352.71
351.96	351.98	352.91	352.67	352.12	356.13	355.19	353.94
352.96	357.25	358.12	354.49	355.90	358.35	358.27	356.64
359.03	357.57	358.11	359.05	359.20	360.09	357.77	361.28
359.25	358.60	358.42	358.25	359.56	357.27	357.72	358.89
358.45	359.19	358.44	358.34	358.45	359.62	359.62	359.32
360.17	357.82	360.40	358.98	360.94	360.50	359.66	361.09

ARRAY OF PRESSURES EVENED

-- FILE - W54503

360.84	359.26	361.22	359.08	360.22	358.41	358.62	356.85
356.94	355.68	356.39	357.26	355.22	356.36	354.26	351.43
354.76	355.14	354.28	352.18	351.94	352.04	351.24	351.83
349.79	349.98	349.02	348.43	348.12	347.04	346.13	346.29
345.50	345.74	344.62	343.58	343.59	342.83	342.40	341.90
342.17	341.49	341.20	340.57	339.36	338.92	338.54	338.91
339.61	338.43	338.58	337.46	337.12	336.95	337.14	334.90
336.72	334.06	334.58	335.44	339.34	338.93	339.69	339.42
337.12	335.14	341.44	339.73	342.36	342.05	345.98	339.78
345.46	347.32	343.45	349.60	346.46	348.54	346.92	350.41
349.23	351.49	350.05	355.06	349.76	352.43	351.21	353.47
353.61	351.88	350.33	353.89	355.73	358.97	356.32	358.96
355.14	361.75	362.09	360.45	361.34	359.01	360.19	362.08
361.69	358.95	362.16	360.85	359.80	359.74	361.22	359.98
359.52	359.22	359.46	360.57	361.91	359.87	361.16	360.49
360.87	361.59	360.63	362.47	361.78	361.48	359.95	358.78
359.88	360.50	358.11	360.08	357.96	358.16	359.39	357.42
357.51	356.45	356.78	356.96	356.55	355.58	355.56	354.36
354.60	354.31	353.53	352.71	353.36	352.53	351.34	350.70
351.04	350.57	350.47	350.03	349.42	350.25	347.65	347.98
347.54	347.00	346.18	346.18	345.86	345.49	345.92	346.23
344.50	344.63	343.77	345.02	343.61	343.82	343.63	343.43
342.52	343.11	344.25	343.52	343.31	341.94	343.60	343.40
342.01	342.47	343.29	343.59	341.44	343.25	345.10	347.27
346.30	343.76	348.39	347.03	348.05	348.29	349.77	351.24
350.27	349.51	351.48	349.90	350.81	350.75	351.77	351.51
350.55	350.67	351.18	353.21	351.24	356.05	355.16	352.85
352.50	355.97	359.61	354.20	355.79	358.49	360.33	356.91
360.90	358.32	359.57	359.27	360.87	362.60	360.19	363.51
362.32	360.99	360.20	359.64	362.38	359.12	360.05	361.01
361.52	361.47	360.17	360.31	360.93	361.50	361.39	360.81
360.75	359.69	362.06	360.74	362.90	361.40	360.39	361.91

ARRAY OF PRESSURES EVENED

-- FILE - W54504

360.25	359.43	359.74	358.71	357.89	357.34	356.08	354.89
354.23	352.42	353.80	353.70	351.22	351.66	350.08	347.64
349.10	348.96	348.15	346.75	345.90	345.64	344.20	343.72
342.94	342.22	341.34	340.59	340.48	339.45	337.93	337.53
337.08	337.28	335.66	334.92	334.42	334.09	333.47	333.05
333.10	332.03	331.57	331.06	330.46	329.91	330.12	330.00
330.31	329.22	329.54	329.23	329.14	327.92	329.15	327.00
331.34	330.70	330.53	332.17	335.62	333.45	337.71	338.71
336.39	335.35	341.01	337.65	343.92	343.20	347.01	341.06
345.65	348.12	342.36	350.55	347.57	349.75	347.00	352.05
349.82	352.71	350.77	354.70	351.12	352.37	352.12	354.56
354.69	353.97	353.75	354.68	356.23	358.68	357.29	359.04
354.90	361.56	360.98	359.76	361.80	360.14	361.16	362.68
362.39	360.53	363.38	362.85	361.11	361.16	362.44	362.14
361.65	361.27	361.26	362.17	362.88	360.93	362.31	361.23
361.62	362.80	361.16	362.26	361.70	361.89	359.84	359.68
359.69	359.96	358.27	358.77	356.76	356.53	356.57	355.99
354.46	353.41	352.94	353.00	352.68	352.28	351.47	349.94
350.06	348.77	348.21	347.38	347.42	346.83	345.65	344.67
344.71	343.68	343.78	343.16	342.55	342.40	341.02	341.02
340.61	339.99	339.58	338.92	339.47	338.32	339.09	338.72
338.91	337.67	336.97	338.35	337.69	337.10	338.09	337.70
337.79	337.65	339.01	338.36	338.98	337.99	338.56	342.02
338.34	338.04	340.46	340.38	339.28	341.98	341.56	345.09
344.46	340.66	344.76	344.74	345.27	346.58	349.72	349.32
349.31	350.57	351.05	348.70	349.80	350.46	352.52	350.17
351.59	350.70	351.70	353.09	349.93	354.21	355.25	353.57
354.44	356.12	358.39	354.84	355.77	357.72	358.81	357.00
359.01	358.91	359.83	359.62	360.35	362.30	360.79	363.03
362.62	361.61	362.00	361.31	363.78	360.87	361.85	361.88
362.15	362.68	361.83	362.52	362.56	363.06	362.18	362.21
362.26	360.67	363.35	361.87	363.43	361.65	361.37	361.61

ARRAY OF PRESSURES EVENED

-- FILE - W54505

358.96	359.40	357.10	358.03	353.67	356.12	352.30	352.54
350.63	348.23	349.95	348.43	345.76	344.51	344.33	343.13
340.61	339.85	339.21	338.87	337.45	336.57	334.29	331.89
333.65	331.77	330.64	329.93	329.66	329.10	327.14	325.57
325.74	325.74	323.49	323.80	321.97	322.63	322.06	321.84
321.23	319.93	319.15	319.03	319.42	318.76	319.79	318.59
318.36	317.48	318.05	319.71	320.01	316.72	319.59	317.95
325.84	322.87	327.41	330.12	332.04	326.99	337.03	339.85
337.84	338.75	341.86	336.27	347.67	345.93	349.38	344.53
346.27	348.62	342.03	352.03	349.11	351.54	347.74	353.33
350.75	354.04	352.20	352.44	353.62	352.47	354.04	356.90
356.17	357.17	359.79	355.70	356.49	357.22	358.45	357.91
354.40	359.70	357.71	357.20	361.22	360.99	361.41	361.66
361.56	361.61	363.15	364.89	362.07	362.12	362.64	364.08
363.42	363.59	363.00	363.49	362.37	361.61	362.93	361.41
362.07	363.71	361.56	360.75	360.55	361.14	359.18	360.77
358.91	359.11	358.20	356.27	355.34	354.62	352.22	353.74
350.26	349.75	347.86	347.25	347.10	347.79	345.80	344.09
343.80	340.95	340.59	339.66	339.17	338.60	337.92	336.49
336.15	334.02	334.58	333.55	333.09	331.50	332.48	331.82
331.10	330.98	331.35	329.41	331.37	329.12	330.64	328.53
331.96	329.10	328.75	329.95	330.76	329.10	331.52	331.10
332.94	331.30	332.87	332.50	334.41	333.97	332.18	342.01
334.83	333.11	337.65	336.91	338.19	341.37	336.74	342.01
342.40	337.21	339.19	342.01	341.00	344.51	349.75	346.03
348.08	352.32	349.58	347.05	347.84	349.85	353.87	348.74
354.06	351.51	353.55	352.59	348.38	351.34	355.41	355.34
357.79	357.10	355.60	356.02	355.80	356.41	355.21	357.00
354.92	359.40	359.40	360.06	358.54	360.36	360.33	360.97
361.31	361.22	363.81	363.15	364.35	362.56	363.35	362.02
361.36	363.25	363.44	364.87	363.71	364.42	362.42	363.57
364.33	361.14	364.42	362.64	363.13	361.51	362.49	360.65

ARRAY OF PRESSURES EVENED

-- FILE - W54506

358.07	354.97	353.36	350.13	348.98	347.50	342.99	343.26
340.96	338.90	338.75	336.80	334.09	331.36	330.93	328.75
328.10	326.47	326.02	324.84	322.11	320.28	320.20	318.17
318.10	316.04	314.67	313.56	312.86	312.49	310.91	310.51
308.85	307.72	307.70	308.30	307.10	305.24	304.42	303.81
304.47	303.89	305.39	302.69	306.92	303.79	302.74	303.06
306.60	305.54	315.04	309.30	310.13	318.48	310.41	325.47
315.59	330.96	343.04	341.16	335.24	341.13	338.85	344.21
341.86	347.50	347.32	349.83	351.86	347.35	351.08	351.43
347.15	350.71	350.23	347.00	349.58	344.99	351.36	350.63
350.68	352.54	357.42	358.00	361.11	361.88	364.79	365.39
362.66	362.84	364.21	368.63	366.90	367.50	363.56	366.85
367.10	366.19	365.19	363.76	368.10	367.15	369.25	368.78
370.03	368.98	370.68	369.48	371.76	370.88	370.63	373.46
371.86	375.22	370.58	371.33	371.63	370.78	369.20	368.53
367.80	367.97	365.74	361.48	360.96	359.78	358.02	360.91
356.55	352.54	351.36	349.03	348.20	344.74	344.87	342.03
340.48	338.40	337.47	336.37	335.99	333.86	332.41	331.28
329.85	329.60	328.20	326.27	326.97	324.49	325.12	324.16
323.09	323.09	321.38	323.26	321.53	319.53	320.88	319.33
318.33	320.43	320.66	318.38	319.50	317.27	320.71	316.85
321.31	318.25	322.79	321.51	323.16	322.28	324.54	327.10
321.38	329.78	336.95	324.04	328.55	327.22	331.23	334.89
338.12	336.12	342.96	340.08	346.07	341.76	345.14	342.49
345.04	341.83	344.74	341.56	345.84	345.49	344.16	345.82
346.12	348.48	346.90	345.74	344.62	347.12	350.58	348.43
351.01	353.04	356.42	358.88	359.75	363.49	365.19	366.82
366.80	366.92	365.19	364.57	365.64	364.39	365.29	366.14
364.06	366.50	364.21	367.07	364.97	367.37	368.20	367.32
367.30	370.05	372.23	372.06	371.73	371.43	370.48	371.03
371.41	369.75	372.51	373.09	371.96	371.58	370.61	371.13
368.37	367.32	367.12	368.05	365.84	364.26	364.29	362.54

ARRAY OF PRESSURES EVENED

-- FILE - W54507

373.26	362.24	362.79	360.11	356.95	348.99	350.96	348.74
345.78	343.13	339.03	336.99	333.30	330.64	328.90	329.02
328.72	325.23	322.68	320.20	317.50	317.90	316.16	314.44
312.85	313.18	311.61	311.51	309.06	309.59	308.98	308.60
308.55	308.63	308.53	307.34	308.93	308.48	307.97	309.31
309.76	311.00	309.31	309.61	311.99	315.25	312.70	314.49
321.32	315.98	319.42	323.62	323.67	329.00	325.28	338.48
333.83	347.27	344.49	347.63	346.06	352.56	341.06	357.99
362.06	363.20	357.94	361.43	367.27	365.77	368.60	371.46
366.18	372.88	371.66	370.37	370.55	368.86	368.23	368.73
372.45	371.33	368.53	369.21	371.11	372.55	372.14	375.33
375.81	377.17	375.99	375.71	377.20	379.07	377.75	379.20
378.97	384.45	381.82	384.40	388.04	386.27	387.84	384.17
389.05	390.47	390.19	390.95	394.33	392.31	392.82	395.65
392.52	393.30	396.18	394.92	394.33	396.28	390.49	387.81
390.09	387.79	384.12	380.79	379.47	375.53	374.57	368.18
367.24	360.52	360.69	355.56	354.37	352.00	347.17	346.24
344.09	341.56	339.44	337.74	334.86	333.62	333.30	334.86
330.09	328.01	328.01	326.19	326.19	323.79	324.47	322.60
323.39	324.96	323.94	325.76	325.11	326.47	324.53	324.37
325.23	326.32	325.33	327.25	326.93	326.98	327.20	325.81
327.36	330.67	328.85	325.13	332.36	328.67	337.39	334.94
329.38	333.70	335.65	340.09	335.87	341.13	340.22	341.43
347.60	352.23	346.31	349.57	352.68	352.38	351.82	353.64
353.19	353.84	348.13	359.28	355.94	358.32	352.66	358.85
361.86	364.18	361.20	362.84	367.24	366.25	364.28	367.09
367.85	369.46	369.64	370.93	369.34	370.70	372.12	371.59
374.95	374.06	372.57	373.61	379.55	376.97	379.95	380.36
379.04	381.42	384.20	384.50	382.58	384.10	386.22	387.01
386.78	388.19	390.59	389.71	390.37	391.45	391.66	393.93
393.96	395.12	392.62	396.10	392.72	394.81	394.28	392.46
390.37	391.00	391.45	388.75	387.43	384.15	379.27	374.92

ARRAY CF PRESSURES EVENED

-- FILE - W54508

343.14	342.20	333.51	332.90	328.66	324.41	322.50	321.63
316.71	312.92	309.53	310.72	308.69	303.05	301.78	301.81
299.68	299.01	297.23	295.87	294.58	295.23	293.05	292.31
291.29	289.71	290.23	289.51	288.72	289.90	288.84	290.89
290.30	290.15	292.53	292.06	290.62	292.90	294.58	291.86
296.36	296.91	292.35	301.78	301.69	303.54	302.11	305.87
323.79	306.69	325.35	332.92	328.04	346.95	339.28	349.11
346.38	336.86	350.02	360.74	356.98	352.47	363.11	356.61
367.10	364.85	372.27	364.85	369.97	368.83	368.54	370.17
367.45	363.88	370.71	367.35	369.35	369.90	373.76	368.36
371.21	372.47	371.63	374.90	376.75	377.49	377.97	379.75
382.89	383.01	380.94	382.52	383.09	386.90	386.01	386.75
384.97	389.23	389.72	395.64	395.71	392.59	399.97	401.16
405.09	404.13	406.28	408.11	411.58	413.28	418.85	417.86
418.23	416.95	420.44	413.56	412.32	405.14	397.79	397.39
392.79	386.58	373.09	372.67	367.79	358.24	356.90	346.56
341.43	336.56	335.12	330.45	330.27	326.81	322.60	321.26
320.30	319.01	317.87	316.04	314.98	314.21	312.90	312.25
312.38	311.21	309.85	311.36	310.50	312.08	310.05	311.12
311.39	311.46	312.50	307.63	308.34	310.05	310.92	310.47
310.00	313.61	310.79	310.37	312.45	315.25	314.88	315.59
318.47	318.37	329.11	323.42	329.95	316.61	334.38	334.33
330.22	341.19	338.12	340.77	339.92	340.17	346.11	342.45
344.28	344.40	345.27	345.59	351.95	346.04	340.59	345.42
354.72	348.86	353.59	360.62	352.70	357.97	364.33	363.66
363.66	362.94	365.74	370.59	369.18	369.28	372.72	372.17
369.72	372.03	374.52	378.11	374.33	377.57	375.86	377.47
379.13	382.07	379.92	380.64	381.36	384.67	380.81	384.42
387.10	388.56	388.73	390.49	389.89	392.05	394.65	395.14
400.24	401.60	404.55	407.94	408.98	411.33	413.88	415.91
417.19	418.16	421.72	417.19	419.74	412.57	413.09	410.54
403.80	399.97	388.68	383.19	378.34	375.61	375.27	363.16

ARRAY CF PRESSURES EVENED

-- FILE - W54509

387.95	378.41	376.93	371.38	359.21	359.61	350.24	348.31
340.00	334.01	322.66	323.41	315.73	309.01	303.63	301.10
301.55	298.06	293.82	291.36	289.00	286.52	286.19	286.11
286.04	286.57	287.60	289.45	286.52	284.68	287.47	293.32
290.98	298.19	295.78	296.56	298.64	306.17	299.92	304.51
315.58	310.29	315.96	318.32	339.98	321.15	349.74	333.63
340.53	341.18	348.39	346.56	356.39	356.24	353.46	359.38
365.28	357.75	362.49	362.37	367.46	363.52	367.99	364.15
370.43	366.84	362.09	375.34	368.67	374.54	375.12	374.59
377.83	374.82	374.85	374.69	374.54	378.08	380.47	377.40
378.48	379.76	384.63	380.54	382.15	384.78	383.23	384.46
386.99	385.39	387.57	388.70	385.51	390.40	392.44	394.42
397.28	398.99	400.29	404.76	403.16	408.00	405.67	409.61
407.05	412.67	411.92	413.67	415.81	413.17	415.53	414.65
415.78	413.90	411.97	408.15	406.17	405.34	403.73	403.83
400.90	402.28	397.03	394.04	390.46	388.32	380.79	374.99
368.87	368.97	364.48	356.60	351.17	346.30	340.81	336.77
333.80	330.82	322.33	320.85	314.65	311.31	308.43	305.47
303.68	302.40	302.40	300.87	302.38	304.19	303.16	305.14
309.36	307.30	311.54	308.38	310.89	311.99	312.07	324.67
319.17	322.79	324.74	331.29	325.95	324.74	331.67	325.95
328.08	333.25	334.43	338.27	337.59	335.91	338.10	341.11
337.12	341.31	332.52	350.22	349.09	343.92	346.23	352.43
344.12	348.26	356.34	355.32	358.65	361.72	361.62	361.11
365.08	362.72	361.62	360.66	366.58	366.13	372.81	370.40
373.26	371.18	369.02	378.61	379.41	380.34	376.30	379.19
381.02	378.48	382.30	382.25	381.57	383.28	385.51	384.88
387.07	387.39	384.53	389.25	390.35	392.39	393.67	395.93
394.57	397.18	397.21	400.29	400.87	401.95	407.00	405.29
411.41	410.86	413.80	415.13	414.30	417.61	418.19	418.72
421.18	421.55	422.48	420.47	420.45	418.32	417.14	420.02
413.87	417.59	416.46	413.25	409.18	410.33	403.43	400.39

ARRAY OF PRESSURES EVENED

-- FILE - W54510

405.01	403.81	403.91	404.71	402.71	403.06	404.18	404.63
406.10	407.48	406.35	405.73	407.65	408.13	407.70	404.61
407.50	403.58	401.14	399.34	396.42	393.85	388.43	381.54
379.25	369.93	359.52	350.01	344.10	336.33	326.25	323.43
318.19	312.15	312.50	312.47	313.27	309.25	308.20	295.32
310.65	287.93	293.37	314.57	315.97	312.79	312.02	321.31
317.16	312.05	321.66	322.28	315.59	323.23	321.91	321.98
327.10	326.77	328.57	330.32	334.31	334.29	334.11	336.01
338.03	338.86	346.39	346.99	348.04	348.27	349.54	354.83
353.93	355.46	358.10	360.00	361.37	365.29	364.67	364.64
367.49	371.13	372.51	374.40	372.68	375.05	376.12	377.87
379.30	381.87	381.49	382.94	385.61	387.41	387.43	386.11
387.08	390.58	388.66	390.00	389.65	393.20	393.60	393.87
394.90	394.90	395.97	393.55	395.07	394.72	395.17	393.10
397.97	394.65	396.57	394.37	395.62	396.54	395.40	395.62
395.95	395.00	396.79	395.67	396.19	394.00	396.37	395.47
396.79	394.40	396.07	396.69	397.94	396.59	399.54	397.49
401.51	403.13	401.66	403.31	402.76	401.99	403.48	405.71
404.83	404.81	405.28	401.04	401.04	395.95	391.20	385.89
382.89	372.28	368.51	356.50	347.82	341.98	337.86	336.58
324.83	325.25	320.36	319.91	309.97	304.96	301.16	297.12
302.78	299.51	298.14	295.32	295.92	302.96	306.50	299.14
307.43	307.10	311.45	308.55	312.55	313.94	310.72	320.11
319.71	322.36	317.64	332.49	331.09	336.73	338.81	337.88
338.96	345.05	345.25	347.62	348.02	353.56	353.68	356.35
357.65	358.60	358.83	360.72	364.77	362.27	365.87	365.97
370.88	368.69	371.78	373.65	374.08	377.72	376.52	380.19
382.04	382.61	384.26	383.19	384.84	385.41	387.38	391.18
388.93	391.73	390.18	392.23	393.47	395.65	395.50	397.37
397.62	397.89	402.96	400.34	401.11	403.68	403.93	405.63
404.86	405.28	406.85	406.68	408.75	406.25	405.73	404.86
409.45	407.98	406.75	405.36	406.78	406.65	406.05	406.25

ARRAY OF PRESSURES EVENED

-- FILE - W54511

402.31	400.95	402.71	402.43	403.01	404.17	404.14	404.14
405.42	404.67	402.38	403.24	401.03	402.86	402.94	401.03
402.51	401.76	402.46	402.51	402.66	403.66	404.07	405.67
407.33	406.35	409.21	411.47	412.25	412.47	413.91	414.66
416.52	416.84	418.72	419.38	419.93	420.58	421.41	423.12
420.91	420.96	422.01	417.95	418.00	414.03	410.69	402.81
398.47	394.98	392.85	387.95	383.73	380.02	374.40	369.58
367.65	365.91	360.52	360.67	358.06	357.00	357.81	356.70
360.77	358.13	353.94	356.65	357.81	363.10	364.83	363.25
364.94	363.30	365.66	368.88	368.02	369.30	369.53	370.86
369.88	370.31	366.59	366.62	365.21	365.56	367.22	368.85
365.99	366.47	365.94	367.67	368.52	366.39	367.80	367.60
370.06	371.69	374.37	376.13	376.08	378.82	379.54	378.79
383.26	386.87	386.27	387.75	389.43	391.09	388.40	391.92
390.56	392.92	391.49	393.57	392.44	392.44	393.25	391.19
392.02	390.69	392.29	392.80	395.13	395.56	392.87	396.51
396.59	398.14	398.09	399.25	401.61	402.38	402.53	402.13
402.33	401.91	401.98	402.79	404.02	404.09	400.40	403.29
403.99	403.66	404.94	403.46	406.27	408.36	407.40	409.76
410.52	412.00	413.30	415.11	416.16	417.54	420.61	421.13
422.67	421.38	422.44	422.34	424.05	424.57	423.67	423.42
424.42	423.77	421.99	419.70	416.47	412.20	405.85	402.46
394.85	394.20	386.97	382.86	385.24	372.82	370.33	364.18
362.32	360.77	358.58	354.39	357.78	353.01	352.41	351.66
354.59	354.77	359.74	357.10	362.70	361.65	360.72	363.13
365.01	363.96	365.99	369.33	369.20	371.34	367.77	366.57
366.54	369.08	369.80	367.75	367.47	367.55	365.99	369.43
370.63	370.93	369.58	369.65	371.01	372.69	374.27	373.47
375.90	378.71	375.28	380.72	382.83	384.89	386.62	389.63
389.58	391.94	393.55	395.98	396.96	396.64	396.01	398.52
398.97	400.25	397.67	398.37	400.15	396.86	399.50	400.50
399.80	398.04	398.29	398.14	399.45	400.65	401.23	403.16

ARRAY CF PRESSURES EVENED

-- FILE - W54512

390.46	391.87	390.76	392.60	395.29	395.32	397.38	398.87
403.32	401.76	402.92	407.05	408.71	408.96	410.02	410.45
412.56	414.50	413.06	414.50	415.48	413.74	416.64	414.80
416.16	413.24	413.47	414.50	414.07	413.09	413.11	412.66
415.88	416.54	417.44	416.36	418.91	419.48	419.46	418.96
419.41	422.05	423.11	424.39	424.75	425.70	425.88	424.87
424.62	426.68	425.10	422.38	425.15	425.10	423.94	423.61
424.67	423.39	421.72	421.88	421.42	421.35	419.43	421.72
418.23	417.87	415.86	412.64	409.31	406.22	400.80	393.83
390.38	386.68	384.64	382.45	376.61	373.79	372.66	372.23
367.95	367.85	368.96	366.09	366.77	366.49	364.98	370.87
368.28	371.65	372.13	374.37	377.97	378.07	375.08	380.51
378.42	382.35	383.38	383.61	381.55	381.12	380.16	377.95
381.37	380.89	379.68	380.82	380.14	380.44	381.70	381.82
384.47	381.27	385.57	384.04	385.37	385.20	386.35	385.88
388.52	386.30	388.17	387.94	389.78	390.58	391.99	392.77
393.43	393.05	395.54	396.22	397.36	398.56	399.97	400.02
403.40	404.00	407.00	406.72	411.18	410.65	410.17	413.67
413.84	414.65	416.26	417.95	416.94	415.93	419.21	417.14
418.02	417.92	415.88	416.79	417.87	416.84	416.69	417.22
417.04	418.00	417.27	419.13	418.96	419.91	419.64	420.57
420.37	422.91	423.56	423.51	424.34	424.17	424.95	425.75
425.43	426.53	428.19	427.69	424.95	423.64	426.94	425.10
422.93	423.44	421.40	420.04	421.75	420.99	419.61	420.52
418.96	417.97	414.75	414.00	412.06	402.89	399.95	395.37
393.08	390.08	385.35	382.60	380.79	377.39	373.36	374.07
371.05	369.16	370.17	369.01	370.29	370.70	372.26	371.05
372.73	374.87	377.59	381.09	382.05	383.38	382.63	383.69
384.49	385.47	385.07	384.04	389.70	384.62	382.98	385.62
384.36	383.91	384.89	382.20	384.44	384.47	386.61	387.23
387.34	389.80	388.49	390.03	390.76	391.04	395.67	394.41
394.54	394.54	394.71	396.35	398.92	397.93	396.42	397.03

ARRAY OF PRESSURES EVENED

-- FILE - W54513

392.03	393.56	394.20	396.27	397.92	398.85	400.03	402.30
404.94	404.96	405.31	408.86	409.13	408.84	408.93	410.44
410.19	411.71	410.32	412.63	412.89	411.57	412.63	413.17
412.89	411.73	411.72	412.54	412.52	411.83	412.29	412.58
413.72	413.71	414.95	413.66	414.87	415.13	414.89	414.93
415.12	416.35	417.27	417.36	418.22	417.89	417.97	417.11
417.63	418.93	416.37	415.58	416.66	417.29	415.80	416.37
415.21	415.27	415.01	413.98	414.44	414.43	413.47	415.15
413.31	413.84	412.75	411.91	409.51	408.34	405.47	402.82
401.53	399.43	398.18	396.75	394.09	392.78	392.06	392.11
389.21	388.88	389.29	388.26	388.32	387.64	386.37	389.05
387.30	389.14	389.87	390.86	392.71	392.56	391.00	394.25
393.01	395.19	395.55	395.82	394.67	394.82	393.75	392.75
394.07	394.24	393.79	394.30	393.23	393.78	393.37	393.66
393.53	391.11	390.79	387.63	387.54	387.51	387.41	386.41
387.66	386.32	388.39	387.78	389.11	390.65	392.44	393.04
393.39	393.81	397.01	399.01	399.40	401.38	403.46	403.52
406.57	406.98	409.16	409.32	412.06	410.82	411.23	412.61
413.29	413.71	413.45	414.03	414.48	413.89	415.27	413.89
414.89	414.86	413.46	414.07	415.13	414.42	414.20	414.31
414.17	415.21	414.40	415.33	415.39	416.30	416.06	416.13
416.47	417.94	417.63	417.75	417.66	417.23	418.59	418.68
417.75	418.54	419.07	419.07	417.44	416.33	418.15	416.82
415.08	416.61	414.90	414.14	415.98	415.35	415.18	415.30
415.20	414.42	412.88	412.35	411.93	407.36	406.21	403.62
403.05	401.24	398.75	398.04	396.91	394.46	392.15	392.98
391.67	389.77	390.31	389.97	389.97	390.00	390.31	389.13
390.85	391.80	392.69	395.27	395.04	396.63	395.55	395.77
397.06	396.64	396.93	396.25	399.19	396.42	395.11	396.42
395.93	395.06	395.17	393.82	394.90	395.70	395.58	394.42
394.65	394.87	391.78	392.29	392.10	391.07	393.46	392.56
392.57	393.25	393.04	394.97	396.54	395.46	396.01	397.36

ARRAY OF PRESSURES EVENED

-- FILE - W54514

393.59	395.25	397.63	399.95	400.55	402.38	402.68	405.73
406.56	408.15	407.70	410.67	409.55	408.71	407.83	410.43
407.81	408.93	407.57	410.75	410.30	409.40	408.63	411.55
409.61	410.22	409.98	410.58	410.97	410.58	411.46	412.49
411.55	410.88	412.45	410.97	410.84	410.77	410.32	410.90
410.84	410.65	411.44	410.32	411.70	410.09	410.07	409.36
410.65	411.18	407.64	408.78	408.18	409.49	407.66	409.12
405.75	407.14	408.30	406.09	407.47	407.51	407.51	408.58
408.39	409.81	409.64	411.18	409.70	410.47	410.13	411.80
412.69	412.17	411.72	411.05	411.57	411.76	411.46	412.00
410.47	409.91	409.61	410.43	409.87	408.80	407.77	407.23
406.33	406.63	407.62	407.36	407.45	407.06	406.93	407.98
407.60	408.03	407.72	408.03	407.79	408.52	407.34	407.55
406.78	407.60	407.90	407.79	406.33	407.12	405.04	405.49
402.59	400.96	396.00	391.23	389.71	389.81	388.46	386.94
386.81	386.34	388.61	387.62	388.44	390.72	392.89	393.31
393.36	394.56	398.47	401.80	401.45	404.20	406.95	407.02
409.74	409.96	411.33	411.91	412.94	410.99	412.30	411.55
412.73	412.77	410.65	410.11	412.02	411.85	411.33	410.65
411.76	411.80	411.03	411.35	412.38	412.00	411.72	411.40
411.29	412.43	411.53	411.53	411.83	412.69	412.49	411.70
412.58	412.96	411.70	412.00	410.97	410.30	412.23	411.61
410.07	410.54	409.94	410.45	409.94	409.01	409.36	408.54
407.23	409.79	408.41	408.24	410.22	409.70	410.75	410.09
411.44	410.86	411.01	410.71	411.80	411.83	412.47	411.87
413.03	412.41	412.15	413.48	413.03	411.53	410.95	411.89
412.30	410.39	410.45	410.92	409.66	409.31	408.37	407.21
408.97	408.73	407.79	409.44	408.03	409.87	408.48	407.85
409.64	407.81	408.80	408.45	408.67	408.22	407.23	407.21
407.49	406.20	405.45	405.45	405.36	406.93	404.55	401.60
401.97	399.93	395.08	394.56	393.44	391.10	391.25	390.72
390.61	391.96	391.36	393.59	394.17	392.99	395.59	397.70

ARRAY OF PRESSURES EVENED

-- FILE - W54515

402.68	403.94	405.76	407.61	407.73	409.48	410.28	411.89
413.09	413.95	414.18	415.59	415.13	414.35	413.89	415.66
414.10	414.46	414.54	416.01	416.21	415.51	415.22	417.76
416.09	416.75	416.35	417.12	416.29	416.76	417.37	417.27
416.81	416.36	417.28	416.44	415.34	415.23	415.22	415.62
415.11	414.56	414.73	414.24	415.16	413.80	414.94	413.99
415.21	415.69	412.79	414.27	413.17	414.70	413.72	414.96
412.74	413.76	413.89	412.26	412.80	412.62	412.68	413.30
412.75	414.31	412.50	414.45	413.18	413.40	413.54	414.74
414.92	414.73	414.58	414.27	414.62	415.24	415.65	415.51
415.12	414.25	414.76	415.47	415.21	414.87	413.53	413.25
412.47	412.49	412.96	411.99	411.53	411.63	410.25	409.91
409.86	409.43	408.27	407.82	407.61	408.02	407.17	407.01
407.28	407.49	407.81	408.59	407.16	408.46	407.32	407.42
405.35	404.88	401.83	399.38	397.97	398.53	398.26	396.99
397.42	396.32	399.22	398.50	399.48	400.62	401.61	402.27
402.35	404.12	406.77	409.24	409.09	411.22	412.17	413.49
414.36	414.94	415.67	415.94	417.46	416.93	416.18	416.61
417.61	417.07	416.19	415.47	417.22	417.45	416.67	416.52
416.85	417.77	417.26	417.41	417.92	417.67	417.46	416.96
417.23	417.26	416.31	416.57	416.53	416.59	416.34	415.94
415.93	416.41	415.31	415.58	414.18	414.48	415.89	415.24
414.07	415.33	413.76	414.46	413.94	413.69	413.53	413.43
412.21	414.19	413.48	413.78	414.44	414.27	414.66	414.26
414.31	414.55	414.50	414.00	414.85	414.79	415.14	414.18
415.98	414.94	414.46	416.12	416.13	415.23	414.65	415.14
415.87	414.72	414.59	415.12	414.36	413.93	413.57	412.24
413.21	413.09	411.72	413.01	412.22	412.59	412.01	410.03
411.23	409.59	408.70	407.82	407.88	408.32	406.92	407.38
407.83	406.63	407.47	407.01	407.15	408.12	407.11	405.03
405.61	405.17	401.59	401.09	400.85	399.41	400.28	400.31
399.83	400.72	399.64	403.19	402.93	402.23	403.79	405.29

ARRAY OF PRESSURES EVENED

-- FILE - W54516

411.77	412.63	413.89	415.27	414.92	416.58	417.88	418.06
419.62	419.75	420.66	420.51	420.70	419.98	419.94	420.89
420.40	420.00	421.51	421.26	422.11	421.63	421.82	423.98
422.56	423.28	422.72	423.65	421.62	422.94	423.27	422.04
422.08	421.85	422.11	421.91	419.84	419.69	420.12	420.34
419.38	418.47	418.03	418.16	418.63	417.51	419.81	418.62
419.77	420.19	417.94	419.77	418.17	419.92	419.79	420.79
419.73	420.37	419.48	418.43	418.13	417.74	417.85	418.01
417.10	418.81	415.37	417.72	416.67	416.32	416.95	417.67
417.16	417.28	417.44	417.49	417.67	418.72	419.84	419.02
419.77	418.58	419.91	420.51	420.55	420.94	419.30	419.26
418.60	418.35	418.30	416.63	415.61	416.21	413.57	411.84
412.13	410.84	408.81	407.61	407.42	407.52	407.01	406.46
407.77	407.38	407.72	409.40	407.99	409.79	409.60	409.35
408.11	408.80	407.66	407.54	406.23	407.25	408.06	407.04
408.03	406.30	409.82	409.38	410.51	410.52	410.33	411.22
411.35	413.69	415.07	416.69	416.72	418.23	417.39	419.96
418.98	419.92	420.02	419.96	421.98	422.87	420.06	421.68
422.50	421.36	421.73	420.84	422.43	423.06	422.01	422.40
421.94	423.74	423.49	423.46	423.45	423.34	423.20	422.53
423.17	422.10	421.10	421.62	421.23	420.49	420.18	420.18
419.28	419.85	418.91	419.16	417.40	418.66	419.54	418.87
418.08	420.13	417.59	418.46	417.94	418.37	417.70	418.31
417.19	418.59	418.55	419.31	418.67	418.84	418.57	418.43
417.18	418.23	417.98	417.30	417.90	417.76	417.81	416.50
418.93	417.47	416.78	418.77	419.23	418.93	418.35	418.39
419.44	419.06	418.73	419.32	419.06	418.55	418.77	417.28
417.45	417.45	415.65	416.57	416.42	415.31	415.55	412.22
412.82	411.36	408.60	407.18	407.10	408.43	406.62	407.55
408.17	407.06	409.49	408.57	408.93	409.31	409.68	408.45
409.25	410.41	408.11	407.62	408.26	407.72	409.31	409.91
409.06	409.48	407.91	412.78	411.68	411.47	412.00	412.89

ARRAY OF PRESSURE COEFFICIENTS

-- FILE - W54501

0.1087	C.1032	0.1108	0.1052	C.1039	0.1101	0.1079	C.1077
0.1075	C.1061	0.1052	0.1044	C.1033	0.0999	0.0995	0.0966
0.0961	C.1001	0.0982	0.0956	C.0935	0.0932	0.0924	C.0918
0.0913	C.0955	0.0935	0.0887	C.0810	0.0822	0.0854	C.0823
0.0801	C.0793	0.0775	0.0756	C.0738	0.0752	0.0782	0.0774
0.0741	C.0766	0.0746	0.0749	C.0708	0.0697	0.0668	0.0642
0.0679	C.0645	0.0645	0.0653	C.0679	0.0621	0.0624	0.0586
0.0600	C.0575	0.0553	0.0567	C.0606	0.0637	0.0641	0.0605
0.0561	C.0545	0.0585	0.0570	C.0587	0.0526	0.0506	C.0511
0.0582	C.0615	0.0647	0.0697	C.0665	0.0639	0.0674	0.0679
0.0684	C.0692	0.0683	0.0685	C.0753	0.0835	0.0821	0.0821
0.0821	C.0772	0.0810	0.0834	C.0863	0.0928	0.0909	C.0893
0.0896	C.0960	0.0982	0.0988	C.0980	0.0939	0.0935	0.0920
0.0908	0.0870	0.0898	0.0924	C.0945	0.0919	0.0918	C.0904
0.0924	C.0948	0.0935	0.0961	C.0960	0.0961	0.0987	0.0990
0.1038	C.1030	0.1068	0.1039	C.1035	0.1035	0.1034	C.1009
0.1033	C.1002	0.0984	0.1046	C.1084	0.1119	0.1090	0.1084
0.1089	C.1117	0.1108	0.1053	C.1041	0.1026	0.1038	0.1036
0.1015	C.1005	0.0954	0.0915	C.0910	0.0919	0.0933	0.0922
0.0949	C.0901	0.0918	0.0883	C.0879	0.0926	0.0882	C.0875
0.0875	C.0874	0.0861	0.0827	C.0824	0.0826	0.0807	0.0794
0.0813	C.0828	0.0811	0.0809	C.0792	0.0775	0.0760	0.0790
0.0775	C.0753	0.0777	0.0769	C.0759	0.0699	0.0679	0.0697
0.0711	C.0698	0.0674	0.0682	C.0691	0.0638	0.0629	0.0655
0.0683	C.0665	0.0676	0.0718	C.0730	0.0730	0.0718	0.0729
0.0761	C.0704	0.0666	0.0673	C.0695	0.0723	0.0803	0.0865
0.0844	C.0841	0.0813	0.0796	C.0829	0.0873	0.0916	0.0961
0.0995	C.0985	0.0971	0.0953	C.0947	0.0950	0.0954	C.0960
0.0991	C.0978	0.0971	0.0985	C.1005	0.1007	0.0970	0.0936
0.0953	C.0954	0.0971	0.0979	C.0975	0.0924	0.0923	0.0976
0.0983	C.0981	0.0973	0.0960	C.0945	0.1014	0.1018	0.1017
0.1085	C.1081	0.1052	0.1051	C.1061	0.1085	0.1060	0.1111

ARRAY OF PRESSURE COEFFICIENTS

-- FILE - W54502

0.1110	C.1C52	0.1128	0.1C99	C.1074	0.1070	0.1063	0.1028
0.1C29	C.0997	0.0978	0.0974	C.0974	0.0980	0.0937	0.0926
0.0929	C.0956	0.0931	0.0894	C.0862	0.0862	0.0843	0.0851
0.0809	C.0788	0.0772	0.0770	C.0725	0.0710	0.0709	0.0696
0.0670	C.0670	0.0640	0.0638	C.0601	0.0594	0.0600	0.0587
0.0576	C.0575	0.0559	C.0548	C.0504	0.0490	0.0469	0.0463
0.0495	C.0455	0.0458	0.0460	C.0446	0.0414	0.0420	0.0416
0.0399	C.0366	0.0334	0.0358	C.0394	0.0432	0.0477	0.0454
0.0388	C.0341	0.0383	C.0443	C.0502	0.0466	0.0435	0.0491
0.0560	C.0559	0.0553	0.0554	C.0563	0.0596	0.0634	0.0642
0.0684	C.0731	0.0735	0.0797	C.0818	0.0821	0.0866	C.0888
0.0837	C.0779	0.0768	0.0849	C.0899	0.0914	0.0934	0.0977
0.1021	C.1C64	0.1082	0.1020	C.1000	0.1001	0.1022	C.1C51
0.1037	C.1C37	0.1C42	C.1C99	C.1019	C.1005	0.1033	C.1002
0.0976	C.1C09	0.1008	0.1042	C.1040	0.1029	0.1066	0.1055
0.1086	C.1C96	0.1096	0.1118	C.1102	0.1065	0.1067	0.1C31
0.1065	C.1120	0.1C98	0.1C75	C.1053	0.1075	0.1084	0.1066
0.1047	C.1C40	0.1C42	0.1018	C.1004	0.0978	0.0983	0.0959
0.0953	C.0943	0.0902	0.0866	C.0863	0.0865	0.0849	0.0831
0.0852	C.0819	0.0825	0.0799	C.0785	C.0769	0.0752	0.0755
0.0715	C.0736	0.0713	0.0696	C.0689	0.0682	0.0712	0.0681
0.0674	C.0667	0.0642	0.0665	C.0629	0.0648	0.0613	0.0624
0.0599	C.0600	0.0634	0.0615	C.0607	0.0590	0.0572	0.0560
0.0557	C.0560	0.0564	0.0573	C.0536	0.0545	0.0576	0.0631
0.0626	C.0648	0.0663	0.0658	C.0646	0.0688	0.0712	0.0745
0.0742	C.0699	0.0719	0.0726	C.0720	0.0733	0.0793	0.0819
0.0789	C.0790	0.0826	0.0859	C.0893	0.0912	0.0915	0.0866
0.0915	C.0994	0.1C28	0.0980	C.1009	0.1037	0.1034	0.1050
0.1063	C.1C46	0.1028	0.1064	C.1070	0.1105	0.1134	0.1110
0.1072	C.1C47	0.1C40	0.1C33	C.1014	0.0995	0.1013	C.1058
0.1041	C.1C69	0.1C40	0.1036	C.1041	0.1086	0.1086	0.1074
0.1108	C.1119	0.1117	0.1128	C.1137	0.1120	0.1088	0.1143

ARRAY CF PRESSURE CCEFFICIENTS

-- FILE - W54503

0.1133	C.1072	0.1148	0.1142	C.1109	0.1039	0.1047	0.0979
0.0982	C.0933	0.0961	0.0995	C.0995	0.0960	0.0879	0.0887
0.0898	C.0912	0.0879	0.0798	C.0789	0.0792	0.0761	0.0784
C.0705	C.0713	0.0675	0.0653	C.0641	0.0599	0.0563	0.0569
0.0539	C.0548	0.0505	0.0465	C.0465	0.0436	0.0419	C.0400
0.0410	C.0384	0.0372	0.0348	C.0301	0.0284	0.0269	0.0283
0.0311	C.0265	0.0271	0.0227	C.0214	0.0208	0.0215	0.0128
0.0099	C.0096	0.0116	0.0149	C.0215	0.0285	0.0314	C.0303
0.0214	C.0137	0.0203	0.0315	C.0417	0.0509	0.0558	0.0552
0.0538	C.0609	0.0663	0.0698	C.0689	0.0657	0.0594	0.0618
0.0684	C.0711	0.0715	C.0697	C.0704	0.0725	0.0760	0.0848
0.0853	C.0786	0.0812	0.0864	C.0936	0.0942	0.0958	C.1060
0.1120	C.1169	0.1182	0.1118	C.1076	0.1063	0.1108	0.1181
0.1166	C.1184	0.1185	0.1134	C.1093	0.1091	0.1148	0.1100
0.1082	C.1071	0.1080	0.1123	C.1175	0.1171	0.1146	0.1120
0.1135	C.1162	0.1186	0.1197	C.1170	0.1158	0.1099	0.1054
0.1096	C.1120	0.1124	0.1104	C.1022	0.1030	0.1015	0.1001
0.1004	C.0963	0.0976	0.0983	C.0967	0.0930	0.0929	C.0882
0.0892	C.0880	0.0850	C.0818	C.0844	0.0812	0.0765	0.0740
0.0754	C.0736	0.0732	0.0715	C.0691	0.0656	0.0622	0.0635
0.0618	C.0597	0.0565	0.0565	C.0553	0.0539	0.0555	0.0567
0.0500	C.0505	0.0472	0.0465	C.0466	0.0474	0.0467	0.0459
0.0424	C.0447	0.0491	0.0462	C.0454	0.0459	0.0466	0.0458
0.0404	C.0422	0.0453	0.0465	C.0450	0.0452	0.0524	0.0545
0.0570	C.0613	0.0651	0.0651	C.0638	0.0647	0.0705	0.0761
0.0724	C.0694	0.0691	0.0709	C.0745	0.0742	0.0782	C.0772
0.0735	C.0739	0.0759	0.0838	C.0903	0.0948	0.0913	0.0824
0.0810	C.0859	0.0908	0.0876	C.0938	0.1042	0.1113	0.1144
0.1136	C.1110	0.1084	0.1072	C.1135	0.1202	0.1245	C.1237
0.1191	C.1139	0.1109	0.1087	C.1064	0.1067	0.1103	0.1140
0.1160	C.1158	0.1107	0.1113	C.1137	0.1159	0.1155	0.1132
0.1130	C.1151	0.1181	0.1219	C.1213	0.1155	0.1116	0.1175

ARRAY OF PRESSURE COEFFICIENTS

-- FILE - W54504

0.1110	C.1C79	0.1C91	0.1C51	C.1019	0.0998	0.0949	0.0903
0.0877	C.0868	0.0860	0.0857	C.0822	0.0778	0.0716	C.0694
0.0679	C.0673	0.0641	0.0587	C.0555	0.0544	0.0489	0.0470
0.0440	C.0412	0.0378	0.0349	C.0345	0.0304	0.0246	C.0230
0.0213	C.0221	0.0158	0.0129	C.0110	0.0097	0.0073	C.0056
0.0059	C.0017	-.0001	-.0021	-.0044	-.0065	-.0057	-.0062
-.0050	-.0092	-.0079	-.0092	-.0095	-.0142	-.0095	-.0048
-.0010	-.0035	-.0041	0.0022	C.0156	0.0197	0.0237	0.0276
0.0268	C.0274	0.0365	0.0442	C.0478	0.0548	0.0597	0.0563
0.0545	C.0640	0.0703	0.0734	C.0715	0.0704	0.0758	C.0793
0.0815	C.0818	0.0743	0.0740	C.0757	C.0805	0.0850	0.0890
0.0895	C.0867	0.0859	0.0895	C.0955	0.0972	0.0996	0.1064
0.1122	C.1161	0.1139	0.1C92	C.1085	C.1106	0.1146	C.1205
0.1194	C.1214	0.1232	0.1211	C.1144	0.1146	0.1195	0.1184
0.1165	C.1150	0.1150	0.1185	C.1212	0.1212	0.1190	0.1148
0.1164	C.1209	0.1205	C.1189	C.1167	0.1174	0.1095	C.1089
0.1C89	C.1C99	0.1C34	0.0999	C.0975	0.0966	0.0968	0.0945
0.0886	C.0846	0.0827	0.0830	C.0817	0.0802	0.0770	C.0711
0.0716	C.0666	0.0644	0.0612	C.0613	0.0590	0.0545	0.0507
C.0508	C.0469	0.0472	0.0448	C.0425	0.0419	0.0365	0.0366
0.0350	C.0326	0.0310	0.0284	C.0305	0.0261	0.0291	0.0276
0.0283	C.0236	0.0208	0.0262	C.0236	0.0214	0.0252	0.0237
0.0240	C.0235	0.0288	0.0262	C.0286	0.0248	0.0270	C.0267
0.0261	C.0250	0.0288	0.0340	C.0363	0.0402	0.0479	C.0523
0.0499	C.0505	0.0510	0.0509	C.0530	0.0581	0.0634	0.0687
0.0687	C.0735	0.0754	0.0729	C.0706	0.0731	0.0728	C.0720
0.0722	C.0741	0.0779	0.0833	C.0858	C.0877	0.0917	0.0904
0.0885	C.0950	0.0930	0.0901	C.0937	0.1012	0.1055	0.1061
0.1062	0.1C58	0.1C94	0.1C86	C.1114	0.1190	0.1215	C.1218
0.1202	C.1163	0.1178	0.1152	C.1137	0.1135	0.1173	0.1174
0.1184	C.1205	0.1172	0.1198	C.1200	0.1219	0.1186	0.1187
0.1189	C.1127	0.1139	0.1173	C.1172	0.1165	0.1154	0.1163

ARRAY OF PRESSURE COEFFICIENTS

-- FILE - W54505

0.1061	C.1078	0.0988	0.1025	C.1005	0.0950	0.0882	0.0812
0.0738	C.0726	0.0711	0.0652	C.0549	0.0500	0.0494	0.0447
0.0350	C.0320	0.0295	0.0282	C.0227	0.0193	0.0105	0.0012
-.0002	C.0007	-.0037	-.0064	-.0075	-.0097	-.0173	-.0233
-.0227	-.0227	-.0314	-.0302	-.0373	-.0347	-.0369	-.0378
-.0401	-.0452	-.0482	-.0487	-.0472	-.0497	-.0457	-.0504
-.0513	-.0547	-.0525	-.0460	-.0449	-.0453	-.0465	-.0529
-.0460	-.0338	-.0162	-.0057	C.0017	0.0112	0.0211	0.0241
0.0242	C.0277	0.0398	0.0514	C.0623	0.0556	0.0510	C.0501
0.0569	C.0660	0.0736	0.0792	C.0784	C.0773	0.0820	0.0842
0.0860	C.0870	0.0799	0.0808	C.0854	0.0809	0.0870	0.0911
0.0952	C.0991	0.0956	0.0934	C.0965	0.0993	0.1041	0.1020
0.1060	C.1089	0.1087	0.1081	C.1148	0.1139	0.1156	0.1165
0.1161	C.1163	0.1223	0.1203	C.1181	0.1183	0.1203	0.1259
0.1233	C.1240	0.1217	0.1236	C.1193	0.1163	0.1214	C.1156
0.1181	C.1245	0.1161	0.1130	C.1122	0.1145	0.1148	0.1131
0.1059	C.1066	0.1031	0.0956	C.0920	0.0893	0.0800	C.0756
0.0724	C.0704	0.0631	0.0607	C.0601	0.0628	0.0551	C.0484
0.0473	C.0363	0.0349	0.0312	C.0293	0.0272	0.0245	0.0190
0.0177	C.0094	0.0116	0.0076	C.0058	-.0004	0.0034	C.0009
-.0019	-.0024	-.0009	-.0084	-.0103	-.0096	-.0110	-.0119
-.0107	-.0097	-.0110	-.0063	-.0032	-.0013	-.0003	-.0019
-.0021	-.0011	0.0049	0.0035	C.0109	0.0092	0.0023	C.0063
0.0125	C.0183	0.0235	0.0206	C.0256	0.0379	0.0392	0.0404
0.0419	C.0361	0.0294	0.0294	C.0365	0.0500	0.0529	0.0559
0.0639	C.0686	0.0697	0.0599	C.0630	0.0707	0.0863	C.0900
0.0871	C.0864	0.0851	0.0814	C.0784	0.0765	0.0826	0.0920
0.1015	C.0988	0.0931	0.0947	C.0938	0.0962	0.0915	0.0985
0.1038	C.1078	0.1078	0.1103	C.1044	0.1115	0.1114	0.1138
0.1152	C.1148	0.1249	0.1223	C.1269	0.1200	0.1231	0.1179
0.1154	C.1227	0.1234	0.1289	C.1245	0.1272	0.1194	0.1239
0.1269	C.1280	0.1272	C.1203	C.1222	0.1159	0.1197	0.1126

ARRAY OF PRESSURE COEFFICIENTS

-- FILE - W54506

0.1026	C.0906	0.0844	0.0718	C.0674	0.0616	0.0538	0.0452
0.0363	C.0283	0.0277	C.0202	C.0097	-.0009	-.0026	-.0110
-.0135	-.0198	-.0216	-.0262	-.0367	-.0438	-.0441	-.0520
-.0523	-.0602	-.0656	-.0699	-.0726	-.0740	-.0802	-.0817
-.0881	-.0925	-.0926	-.0903	-.0949	-.1021	-.1053	-.1076
-.1051	-.1074	-.1015	-.0971	-.0956	-.1077	-.1118	-.1106
-.1066	-.1009	-.0934	-.0864	-.0832	-.0824	-.0821	-.0860
-.0620	-.0156	0.0257	0.0371	C.0372	0.0370	0.0281	C.0300
0.0398	C.0504	0.0610	0.0707	C.0785	0.0782	0.0755	C.0769
0.0756	C.0741	0.0722	0.0706	C.0697	C.0746	0.0766	0.0738
0.0740	C.0812	0.0915	0.1023	C.1144	0.1174	0.1287	0.1310
0.1204	C.1211	0.1264	0.1317	C.1368	0.1391	0.1378	0.1366
0.1376	C.1341	0.1302	0.1247	C.1295	0.1378	0.1459	0.1441
0.1490	C.1449	0.1515	0.1548	C.1557	0.1523	0.1513	0.1540
0.1560	C.1524	0.1511	0.1540	C.1552	C.1519	0.1457	0.1431
0.1403	C.1410	0.1323	0.1158	C.1138	0.1092	0.1024	0.0996
0.0967	C.0812	0.0766	0.0676	C.0644	0.0587	0.0514	C.0405
0.0344	C.0264	0.0228	0.0185	C.0171	0.0088	0.0032	-.0012
-.0067	-.0077	-.0131	-.0206	-.0179	-.0275	-.0251	-.0288
-.0330	-.0330	-.0396	-.0323	-.0390	-.0467	-.0415	-.0475
-.0514	-.0433	-.0424	-.0512	-.0468	-.0446	-.0422	-.0389
-.0399	-.0371	-.0341	-.0391	-.0327	-.0361	-.0273	-.0174
-.0081	-.0070	-.0191	-.0292	-.0286	-.0169	-.0014	0.0128
0.0253	C.0364	0.0363	0.0329	C.0345	0.0394	0.0419	0.0422
0.0385	C.0397	0.0510	0.0540	C.0552	0.0539	0.0487	C.0551
0.0563	C.0654	0.0593	0.0548	C.0505	C.0602	0.0619	0.0652
0.0752	C.0831	0.0962	0.1057	C.1091	0.1236	0.1302	0.1365
0.1364	C.1369	0.1302	0.1278	C.1320	0.1271	0.1306	0.1339
0.1358	C.1353	0.1264	0.1259	C.1293	0.1387	0.1419	0.1385
0.1384	C.1490	0.1575	0.1568	C.1556	0.1544	0.1507	0.1528
0.1543	C.1564	0.1586	C.1608	C.1564	0.1550	0.1512	0.1532
0.1425	C.1385	0.1377	C.1413	C.1327	0.1266	0.1267	0.1199

ARRAY CF PRESSURE CCEFFICIENTS

-- FILE - W54507

0.1615	C.1188	0.1209	0.1105	C.0983	C.0864	0.0751	C.0664
0.0550	C.0447	0.0288	C.0209	C.0066	-.0037	-.0104	-.0099
-.0111	-.0246	-.0345	-.0441	-.0546	-.0530	-.0598	-.0665
-.0726	-.0714	-.0774	-.0778	-.0873	-.0853	-.0876	-.0891
-.0893	-.0890	-.0894	-.0940	-.0878	-.0896	-.0915	-.0863
-.0846	-.0798	-.0863	-.0852	-.0760	-.0746	-.0732	-.0663
-.0645	-.0605	-.0472	-.0403	-.0307	-.0100	0.0082	C.0267
C.0504	C.0608	0.0603	0.0621	C.0715	0.0812	0.0916	0.1023
0.1181	C.1225	0.1190	0.1156	C.1206	0.1325	0.1434	0.1545
0.1611	C.1600	0.1553	C.1503	C.1510	0.1444	0.1420	0.1439
0.1491	C.1540	0.1431	0.1458	C.1531	0.1587	0.1571	0.1695
0.1713	C.1766	0.1720	0.1710	C.1767	0.1840	0.1789	C.1845
0.1836	C.1878	0.1947	0.2046	C.2086	0.2119	0.2180	0.2202
0.2227	C.2282	0.2271	0.2300	C.2327	0.2353	0.2373	C.2366
0.2361	C.2391	0.2423	0.2454	C.2431	0.2365	0.2283	C.2271
0.2267	C.2178	0.2036	0.1906	C.1855	0.1703	0.1556	0.1418
0.1381	C.1267	0.1128	0.0929	C.0883	0.0791	0.0604	C.0568
0.0484	C.0386	0.0304	0.0238	C.0127	0.0079	0.0066	0.0010
-.0058	-.0139	-.0139	-.0209	-.0209	-.0302	-.0276	-.0348
-.0318	-.0257	-.0296	-.0226	-.0251	-.0198	-.0274	-.0280
-.0246	-.0204	-.0242	-.0168	-.0181	-.0179	-.0170	-.0224
-.0164	-.0136	-.0106	-.0059	C.0030	0.0171	0.0225	C.0130
0.0088	C.0082	0.0157	0.0330	C.0372	0.0370	0.0334	C.0381
0.0485	C.0588	0.0570	0.0697	C.0817	0.0806	0.0784	0.0854
0.0837	C.0862	0.0966	0.1073	C.1078	0.1036	0.1033	0.1056
0.1173	C.1156	0.1147	0.1211	C.1277	0.1343	0.1370	0.1376
0.1405	C.1468	0.1474	0.1524	C.1463	0.1516	0.1570	0.1550
0.1599	C.1646	0.1588	0.1628	C.1689	0.1759	0.1874	C.1890
0.1839	C.1931	0.2039	0.2050	C.1976	0.2035	0.2117	0.2147
0.2139	C.2193	0.2286	0.2252	C.2278	0.2320	0.2328	0.2416
0.2417	C.2462	0.2365	0.2348	C.2369	0.2450	0.2429	C.2359
0.2278	C.2302	0.2320	0.2215	C.2164	0.2037	0.1848	0.1679

ARRAY OF PRESSURE COEFFICIENTS

-- FILE - W54508

0.0448	C.0411	0.0075	0.0051	-.0113	-.0278	-.0352	-.0386
-.0577	-.0723	-.0855	-.0809	-.0887	-.1106	-.1155	-.1154
-.1237	-.1262	-.1332	-.1384	-.1434	-.1409	-.1494	-.1522
-.1562	-.1623	-.1603	-.1631	-.1661	-.1615	-.1657	-.1577
-.1600	-.1606	-.1514	-.1532	-.1588	-.1499	-.1434	-.1396
-.1365	-.1344	-.1245	-.1155	-.1159	-.1087	-.1143	-.0997
-.0623	-.0381	-.0242	-.0201	-.0137	0.0036	0.0298	0.0469
0.0573	C.0605	0.0714	0.0854	C.0844	0.0809	0.0803	0.0969
0.1136	C.1289	0.1269	0.1289	C.1366	0.1443	0.1432	0.1495
0.1389	C.1251	0.1304	0.1386	C.1463	0.1484	0.1448	0.1425
0.1535	C.1584	0.1552	0.1678	C.1750	0.1779	0.1797	0.1866
0.1988	C.1993	0.1912	0.1974	C.1996	0.2143	0.2109	C.2138
0.2068	C.2233	0.2371	0.2482	C.2485	0.2568	0.2650	C.2696
0.2848	C.2811	0.2894	0.2965	C.3100	0.3166	0.3256	C.3343
0.3358	C.3308	0.3243	0.3176	C.3128	0.2850	0.2701	0.2550
0.2372	C.2131	0.1863	0.1592	C.1403	0.1033	0.0795	0.0580
0.0381	C.0192	0.0137	-.0044	-.0051	-.0185	-.0348	-.0400
-.0438	-.0488	-.0532	-.0603	-.0644	-.0674	-.0724	-.0749
-.0745	-.0790	-.0842	-.0784	-.0817	-.0756	-.0835	-.0793
-.0783	-.0780	-.0740	-.0929	-.0901	-.0835	-.0801	-.0818
-.0837	-.0827	-.0806	-.0822	-.0742	-.0633	-.0648	-.0620
-.0509	-.0512	-.0445	-.0317	-.0064	0.0040	0.0108	C.0106
0.0236	0.0372	0.0398	0.0356	C.0323	0.0333	0.0371	0.0421
0.0492	C.0497	0.0530	0.0543	C.0553	0.0560	0.0538	0.0536
0.0599	C.0669	0.0852	0.0807	C.0818	0.1022	0.1269	0.1243
0.1243	C.1215	0.1323	0.1397	C.1457	0.1460	0.1594	0.1573
0.1478	C.1567	0.1664	0.1803	C.1821	0.1782	0.1716	0.1778
0.1842	C.1956	0.1873	C.1901	C.1928	C.1908	0.1907	0.2047
0.2151	C.2208	0.2214	0.2282	C.2259	0.2343	0.2443	0.2463
0.2660	0.2713	0.2827	0.2959	C.2999	0.3090	0.3189	C.3267
0.3317	C.3355	0.3362	0.3317	C.3210	0.3138	0.3158	C.3059
0.2798	C.2497	0.2212	0.1999	C.1811	0.1706	0.1693	0.1224

ARRAY OF PRESSURE CCEFFICIENTS

-- FILE - W54509

0.2184	0.1814	0.1757	0.1542	0.1317	0.1086	0.0867	0.0648
0.0326	0.0094	-0.0105	-0.0317	-0.0615	-0.0875	-0.1083	-0.1182
-0.1164	-0.1299	-0.1464	-0.1559	-0.1650	-0.1747	-0.1759	-0.1762
-0.1765	-0.1745	-0.1705	-0.1633	-0.1747	-0.1818	-0.1710	-0.1483
-0.1344	-0.1294	-0.1388	-0.1358	-0.1277	-0.1259	-0.1227	-0.1049
-0.0940	-0.0826	-0.0606	-0.0142	0.0325	0.0684	0.0703	0.0521
0.0346	0.0372	0.0651	0.0840	0.0961	0.0955	0.0997	0.1077
0.1305	0.1314	0.1198	0.1193	0.1202	0.1237	0.1411	0.1504
0.1505	0.1366	0.1182	0.1240	0.1437	0.1664	0.1687	0.1682
0.1792	0.1675	0.1678	0.1670	0.1664	0.1802	0.1894	0.1775
0.1817	0.1867	0.1884	0.1897	0.1959	0.2061	0.2001	0.2049
0.2147	0.2085	0.2169	0.2213	0.2238	0.2279	0.2358	0.2435
0.2546	0.2612	0.2662	0.2718	0.2773	0.2798	0.2871	0.3023
0.3100	0.3142	0.3113	0.3181	0.3263	0.3161	0.3253	0.3219
0.3262	0.3190	0.3115	0.2967	0.2890	0.2858	0.2796	0.2799
0.2686	0.2615	0.2536	0.2420	0.2281	0.2198	0.1907	0.1682
0.1445	0.1448	0.1274	0.0969	0.0759	0.0570	0.0357	0.0201
0.0086	-0.0030	-0.0199	-0.0416	-0.0656	-0.0786	-0.0898	-0.1012
-0.1081	-0.1131	-0.1131	-0.1190	-0.1132	-0.1062	-0.1102	-0.1025
-0.0862	-0.0941	-0.0939	-0.0900	-0.0802	-0.0759	-0.0757	-0.0621
-0.0481	-0.0341	-0.0265	-0.0227	-0.0219	-0.0265	-0.0252	-0.0219
-0.0136	0.0064	0.0110	0.0259	0.0233	0.0167	0.0252	0.0207
0.0214	0.0377	0.0552	0.0722	0.0678	0.0622	0.0567	0.0517
0.0486	0.0646	0.0784	0.0919	0.1049	0.1167	0.1163	0.1144
0.1298	0.1206	0.1163	0.1127	0.1210	0.1339	0.1416	0.1504
0.1615	0.1655	0.1685	0.1822	0.1853	0.1889	0.1875	0.1844
0.1915	0.1947	0.1965	0.1963	0.1937	0.2003	0.2089	0.2065
0.2150	0.2162	0.2197	0.2234	0.2277	0.2356	0.2406	0.2493
0.2441	0.2542	0.2543	0.2662	0.2685	0.2727	0.2922	0.3031
0.3093	0.3072	0.3186	0.3237	0.3205	0.3333	0.3356	0.3376
0.3472	0.3486	0.3522	0.3444	0.3443	0.3361	0.3315	0.3427
0.3380	0.3333	0.3289	0.3164	0.3007	0.3051	0.2784	0.2666

ARRAY OF PRESSURE COEFFICIENTS

-- FILE - W54510

0.2845	C.2799	0.2802	0.2833	C.2756	0.2769	0.2813	0.2830
0.2888	C.2941	0.2897	0.2873	C.2947	0.2966	0.2949	C.2829
0.2814	C.2790	0.2695	0.2625	C.2512	0.2413	0.2203	C.1936
0.1727	C.1486	0.1082	0.0714	C.0485	0.0184	-.0079	-.0316
-.0519	-.0754	-.0740	-.0741	-.0710	-.0866	-.1135	-.1406
-.1620	-.1692	-.1481	-.1113	-.0793	-.0728	-.0758	-.0659
-.0559	-.0471	-.0385	-.0361	-.0340	-.0324	-.0375	-.0372
-.0281	-.0187	-.0117	-.0049	C.0105	0.0104	0.0098	C.0171
0.0250	C.0420	0.0574	0.0597	C.0637	0.0646	0.0696	0.0780
0.0866	C.0925	0.1027	0.1101	C.1154	0.1217	0.1282	0.1281
0.1391	C.1532	0.1585	0.1659	C.1592	0.1684	0.1726	C.1793
0.1849	C.1948	0.1934	C.1990	C.2093	0.2163	0.2164	0.2113
0.2150	C.2181	0.2211	0.2264	C.2250	0.2387	0.2403	C.2414
0.2453	C.2453	0.2495	0.2401	C.2460	0.2446	0.2464	0.2384
0.2400	C.2444	0.2518	0.2433	C.2481	0.2517	0.2473	0.2481
0.2494	C.2457	0.2527	0.2483	C.2503	0.2510	0.2510	0.2475
0.2527	C.2434	0.2499	0.2523	C.2571	0.2519	0.2511	0.2554
0.2710	C.2772	0.2715	0.2779	C.2758	0.2728	0.2786	0.2872
0.2838	C.2837	0.2856	0.2820	C.2691	0.2494	0.2310	C.2104
0.1988	C.1763	0.1431	0.0965	C.0629	0.0402	0.0243	0.0193
-.0021	-.0246	-.0435	-.0636	-.0838	-.1032	-.1179	-.1336
-.1316	-.1243	-.1296	-.1318	-.1266	-.1110	-.0972	-.0946
-.0936	-.0949	-.0939	-.0893	-.0738	-.0684	-.0562	-.0445
-.0460	-.0358	-.0161	0.0035	C.0144	0.0199	0.0280	0.0244
0.0285	C.0405	0.0529	0.0621	C.0637	0.0746	0.0856	0.0960
0.1010	C.1047	0.1055	0.1129	C.1286	0.1316	0.1328	0.1332
0.1372	C.1437	0.1557	0.1630	C.1646	0.1682	0.1741	0.1883
0.1955	C.1977	0.2041	0.1999	C.2063	0.2086	0.2162	0.2309
0.2345	C.2330	0.2270	0.2350	C.2398	0.2482	0.2476	C.2549
0.2559	C.2569	0.2609	0.2664	C.2694	0.2794	0.2803	C.2869
0.2839	C.2856	0.2917	0.2910	C.2902	0.2893	0.2873	0.2960
0.3017	C.2960	0.2913	0.2858	C.2914	0.2909	0.2886	C.2893

ARRAY CF PRESSURE CCEFFICIENTS

-- FILE - W54511

0.2740	C.2688	0.2756	0.2745	C.2768	0.2812	0.2811	0.2811
0.2861	C.2832	0.2743	0.2696	C.2691	0.2762	0.2765	0.2758
0.2748	C.2719	0.2746	0.2748	C.2754	0.2793	0.2809	0.2871
0.2935	C.2974	0.3008	0.3095	C.3126	0.3134	0.3190	0.3219
0.3291	C.3304	0.3377	0.3402	C.3423	0.3449	0.3481	C.3476
0.3461	C.3463	0.3504	0.3461	C.3348	0.3195	0.2978	0.2760
0.2592	C.2456	0.2374	0.2184	C.2021	0.1877	0.1659	0.1472
0.1397	C.1330	0.1229	0.1127	C.1026	0.0985	0.1016	0.0973
0.0998	C.1029	0.1009	0.0971	C.1016	0.1221	0.1288	0.1227
0.1207	C.1229	0.1320	0.1366	C.1412	0.1461	0.1470	C.1522
0.1484	C.1418	0.1356	C.1357	C.1303	0.1316	0.1381	0.1444
0.1420	C.1351	0.1331	0.1398	C.1431	0.1418	0.1403	0.1395
0.1491	C.1554	0.1658	0.1726	C.1724	0.1830	0.1858	C.1921
0.2002	C.2061	0.2119	0.2176	C.2241	0.2306	0.2338	0.2338
0.2285	C.2288	0.2321	0.2402	C.2358	0.2358	0.2389	C.2374
0.2342	C.2290	0.2352	0.2372	C.2462	0.2479	0.2497	C.2516
0.2519	C.2579	0.2577	0.2622	C.2713	0.2743	0.2749	0.2734
0.2741	C.2725	0.2728	0.2759	C.2807	0.2809	0.2793	0.2778
0.2806	C.2793	0.2843	0.2869	C.2894	0.2975	0.3002	C.3029
0.3058	C.3116	0.3166	0.3236	C.3277	0.3331	0.3449	C.3470
0.3529	C.3480	0.3520	0.3517	C.3583	C.3603	0.3568	C.3558
0.3597	C.3572	0.3503	0.3414	C.3289	0.3124	0.2878	0.2746
0.2596	C.2426	0.2208	0.1987	C.1791	0.1598	0.1407	0.1263
0.1191	C.1131	0.1046	0.0884	C.0855	0.0830	0.0807	C.0778
0.0891	C.0992	0.1091	0.1184	C.1206	0.1165	0.1129	0.1222
0.1295	C.1317	0.1396	0.1462	C.1457	0.1432	0.1402	0.1355
0.1354	C.1453	0.1481	0.1401	C.1390	0.1393	0.1425	0.1466
0.1513	C.1525	0.1472	0.1475	C.1528	0.1593	0.1654	0.1687
0.1717	C.1826	0.1868	0.1904	C.1986	0.2065	0.2132	C.2190
0.2247	C.2339	0.2401	0.2495	C.2533	0.2521	0.2556	0.2594
0.2611	C.2583	0.2560	0.2588	C.2657	0.2648	0.2631	C.2670
0.2643	C.2575	0.2585	0.2579	C.2630	0.2676	0.2699	C.2773

ARRAY CF PRESSURE CCEFFICIENTS

-- FILE - W54512

0.2281	C.2336	0.2293	0.2364	C.2468	0.2469	0.2549	0.2607
0.2663	0.2719	0.2764	0.2924	C.2988	0.2998	0.3039	C.3056
0.3138	C.3213	0.3225	0.3213	C.3251	0.3184	0.3196	0.3225
0.3198	C.3164	0.3173	0.3213	C.3196	0.3158	0.3159	C.3213
0.3266	C.3292	0.3327	0.3356	C.3384	0.3406	0.3405	C.3385
0.3403	C.3505	0.3546	0.3596	C.3610	0.3647	0.3654	0.3615
0.3605	C.3615	0.3624	0.3625	C.3625	0.3624	0.3579	C.3566
0.3607	C.3557	0.3493	C.3499	C.3481	C.3478	0.3404	0.3378
0.3357	C.3344	0.3266	0.3141	C.3012	0.2892	0.2682	0.2478
0.2278	C.2135	0.2056	C.1902	C.1745	0.1635	0.1591	0.1575
0.1494	C.1405	0.1350	0.1337	C.1363	0.1352	0.1294	0.1331
0.1422	C.1496	0.1571	0.1658	C.1797	0.1801	0.1749	0.1717
0.1815	C.1967	0.2007	0.2016	C.1936	0.1919	0.1882	C.1903
0.1929	C.1910	0.1864	0.1908	C.1881	0.1893	0.1942	0.1947
0.2049	C.2088	0.2092	0.2088	C.2084	0.2077	0.2122	0.2104
0.2105	C.2120	0.2192	0.2184	C.2255	0.2286	0.2341	0.2371
0.2396	C.2382	0.2478	0.2505	C.2548	0.2595	0.2650	0.2652
0.2712	C.2806	0.2922	0.3032	C.3084	0.3064	0.3124	C.3181
0.3187	C.3219	0.3281	0.3346	C.3307	0.3268	0.3275	0.3315
0.3349	C.3346	0.3323	0.3302	C.3344	0.3304	0.3298	0.3318
0.3311	C.3348	0.3320	C.3392	C.3385	0.3423	0.3412	0.3448
0.3440	C.3539	0.3564	0.3562	C.3594	0.3587	0.3618	0.3649
0.3636	C.3679	0.3744	0.3724	C.3618	0.3567	0.3594	0.3624
0.3614	C.3559	0.3480	0.3427	C.3494	0.3465	0.3411	0.3446
0.3385	C.3347	0.3223	0.3103	C.2983	0.2828	0.2649	0.2471
0.2383	C.2267	0.2083	0.1977	C.1907	0.1775	0.1711	0.1646
0.1529	C.1456	0.1434	0.1450	C.1500	0.1515	0.1519	0.1529
0.1594	C.1677	0.1783	0.1918	C.1955	0.2007	0.1978	C.2019
0.2050	C.2088	0.2072	0.2032	C.2038	0.2055	0.2075	C.2094
0.2045	C.2028	0.2066	0.2058	C.2048	0.2049	0.2132	0.2156
0.2160	C.2176	0.2205	0.2265	C.2293	0.2304	0.2372	0.2434
0.2439	C.2439	0.2446	0.2509	C.2552	0.2571	0.2512	0.2536

ARRAY CF PRESSURE COEFFICIENTS

-- FILE - W54513

0.2342	C.2401	0.2426	0.2507	C.2570	0.2606	0.2652	0.2740
0.2790	C.2843	0.2924	0.2994	C.3005	0.2993	0.2997	0.3015
0.3046	C.3105	0.3124	0.3140	C.3151	0.3147	0.3140	0.3161
0.3150	C.3105	0.3105	0.3137	C.3136	0.3110	0.3127	C.3138
0.3182	C.3182	0.3181	0.3180	C.3227	0.3237	0.3228	0.3229
0.3237	C.3284	0.3320	0.3324	C.3357	0.3344	0.3347	0.3314
0.3334	C.3311	0.3285	C.3255	C.3297	0.3321	0.3313	0.3285
0.3240	C.3243	0.3233	0.3193	C.3211	0.3210	0.3173	0.3164
0.3167	C.3187	0.3145	0.3112	C.3059	0.2974	0.2863	0.2760
0.2710	C.2629	0.2580	0.2525	C.2422	0.2371	0.2343	0.2287
0.2233	C.2220	0.2236	0.2196	C.2198	0.2172	0.2123	0.2121
0.2159	C.2230	0.2259	0.2297	C.2368	0.2363	0.2302	0.2323
0.2380	C.2464	0.2479	0.2489	C.2444	0.2450	0.2409	0.2415
0.2421	C.2428	0.2410	0.2430	C.2389	0.2410	0.2394	C.2405
0.2400	C.2307	0.2222	0.2172	C.2168	0.2167	0.2163	C.2164
0.2173	C.2193	0.2201	0.2177	C.2229	0.2289	0.2358	0.2381
0.2395	C.2458	0.2535	0.2613	C.2628	0.2705	0.2785	0.2853
0.2906	C.2921	0.3006	0.3012	C.3041	C.3070	0.3086	0.3140
0.3166	C.3182	0.3172	0.3195	C.3212	0.3189	0.3183	C.3189
0.3228	C.3227	0.3211	0.3196	C.3237	0.3210	0.3201	C.3205
0.3200	C.3201	0.3209	0.3245	C.3247	0.3283	0.3273	0.3276
0.3289	C.3346	0.3334	0.3339	C.3335	0.3319	0.3371	C.3375
0.3339	C.3369	0.3390	C.3390	C.3327	C.3284	0.3292	C.3263
0.3235	C.3225	0.3229	0.3252	C.3270	0.3246	0.3239	0.3244
0.3240	C.3210	0.3150	0.3130	C.3113	0.3018	0.2892	0.2791
0.2769	C.2699	0.2602	0.2575	C.2531	0.2436	0.2407	0.2379
0.2328	C.2298	0.2275	0.2262	C.2262	0.2264	0.2276	0.2284
0.2296	C.2333	0.2368	0.2410	C.2459	C.2471	0.2479	0.2487
0.2537	C.2521	0.2532	0.2505	C.2507	0.2512	0.2514	0.2512
0.2493	C.2459	0.2464	0.2458	C.2453	0.2484	0.2479	C.2435
0.2444	C.2452	0.2410	0.2352	C.2345	0.2374	0.2398	0.2363
0.2363	C.2389	0.2428	0.2456	C.2466	0.2475	0.2496	0.2549

ARRAY OF PRESSURE CCEFFICIENTS

-- FILE - W54514

0.2403	C.2467	0.2559	0.2649	C.2672	0.2743	0.2810	0.2873
0.2905	C.2967	0.3031	0.3064	C.3021	0.2989	0.2954	0.2943
0.2954	C.2997	0.3038	0.3066	C.3050	0.3015	0.2985	C.2998
0.3024	C.3047	0.3038	0.3061	C.3076	C.3061	0.3095	0.3135
0.3098	C.3073	0.3073	0.3076	C.3071	0.3068	0.3051	C.3073
0.3071	C.3063	0.3094	0.3091	C.3045	0.3042	0.3041	C.3014
0.3063	C.3084	0.3042	0.2991	C.2968	0.2959	0.2948	0.2889
0.2874	C.2928	0.2973	0.2962	C.2940	0.2942	0.2942	C.2964
0.2976	C.3031	0.3024	0.3024	C.3027	0.3057	0.3043	C.3108
0.3143	C.3123	0.3105	0.3079	C.3099	0.3107	0.3095	0.3116
0.3057	C.3035	0.3024	0.3055	C.3034	0.2992	0.2952	C.2931
0.2896	C.2908	0.2946	0.2936	C.2939	C.2924	0.2919	0.2960
0.2945	C.2962	0.2950	0.2962	C.2953	0.2981	0.2935	0.2944
0.2914	C.2945	0.2957	0.2953	C.2940	0.2927	0.2914	C.2864
0.2751	C.2627	0.2496	0.2367	C.2301	0.2256	0.2204	0.2145
0.2140	C.2121	0.2142	0.2171	C.2203	0.2291	0.2375	C.2392
0.2394	C.2440	0.2541	C.2645	C.2707	0.2814	0.2920	C.2994
0.3029	C.3037	0.3090	0.3113	C.3153	0.3148	0.3128	0.3098
0.3144	C.3146	0.3115	0.3090	C.3117	0.3110	0.3090	C.3063
0.3107	C.3108	0.3078	0.3091	C.3131	0.3116	0.3105	0.3093
0.3088	C.3133	0.3098	0.3098	C.3109	0.3143	0.3135	C.3104
0.3138	C.3153	0.3104	0.3116	C.3076	0.3050	0.3073	C.3057
0.3041	C.3059	0.3036	0.3056	C.3036	0.3000	0.3014	0.2982
0.2931	C.2946	0.2977	0.2970	C.2995	0.3027	0.3068	0.3091
0.3094	C.3072	0.3078	0.3066	C.3108	C.3109	0.3134	C.3111
0.3156	C.3132	0.3122	0.3173	C.3156	0.3098	0.3075	0.3112
0.3082	C.3053	0.3056	0.3074	C.3025	0.3012	0.2975	C.2985
0.2999	0.2989	0.3000	0.3017	C.3041	0.3034	0.2979	0.2955
0.2948	C.2954	0.2992	0.2979	C.2987	0.2969	0.2931	0.2930
0.2941	C.2891	0.2862	0.2862	C.2859	0.2848	0.2827	C.2786
0.2727	C.2648	0.2541	0.2440	C.2397	0.2354	0.2312	0.2291
0.2287	C.2339	0.2372	0.2403	C.2382	0.2379	0.2480	C.2562

ARRAY OF PRESSURE COEFFICIENTS

-- FILE - W54515

0.2755	C.2803	0.2874	0.2946	C.2990	0.3018	0.3049	0.3112
0.3158	C.3192	0.3201	0.3222	C.3237	0.3207	0.3189	C.3189
0.3198	C.3211	0.3215	0.3271	C.3279	0.3252	0.3241	C.3254
0.3274	C.3300	0.3285	0.3279	C.3282	0.3301	0.3324	0.3320
0.3303	C.3285	0.3285	0.3288	C.3245	0.3241	0.3241	C.3256
0.3236	C.3215	0.3222	0.3203	C.3238	0.3240	0.3230	0.3232
0.3240	C.3259	0.3237	0.3204	C.3161	0.3169	0.3183	0.3157
0.3145	C.3184	0.3189	0.3167	C.3147	0.3140	0.3142	C.3166
0.3186	C.3205	0.3220	0.3211	C.3162	0.3170	0.3176	0.3222
0.3229	C.3222	0.3216	C.3204	C.3218	0.3242	0.3257	C.3252
0.3237	C.3203	0.3223	0.3250	C.3240	0.3227	0.3175	C.3164
0.3134	C.3135	0.3153	0.3116	C.3098	0.3102	0.3048	0.3035
0.3033	C.3016	0.2971	0.2954	C.2946	0.2962	0.2929	0.2923
0.2933	C.2941	0.2953	0.2984	C.2991	0.2979	0.2935	0.2938
0.2909	C.2840	0.2722	0.2627	C.2606	0.2594	0.2584	0.2567
0.2551	C.2587	0.2588	0.2593	C.2631	0.2675	0.2713	0.2739
0.2742	C.2811	0.2913	0.2961	C.3003	0.3086	0.3123	0.3174
0.3208	C.3230	0.3258	0.3269	C.3288	0.3307	0.3278	0.3295
0.3334	C.3312	0.3278	0.3294	C.3318	0.3327	0.3297	0.3291
0.3304	C.3340	0.3320	0.3325	C.3345	0.3336	0.3327	C.3308
0.3319	C.3320	0.3283	0.3293	C.3291	0.3294	0.3284	C.3269
0.3268	C.3287	0.3244	0.3214	C.3200	0.3212	0.3228	0.3242
0.3196	C.3180	0.3184	0.3211	C.3191	0.3181	0.3175	0.3171
0.3185	C.3201	0.3173	0.3185	C.3211	0.3204	0.3219	C.3204
0.3206	C.3215	0.3213	0.3194	C.3227	0.3224	0.3238	0.3201
0.3213	C.3230	0.3252	0.3276	C.3276	0.3241	0.3219	0.3238
0.3230	C.3222	0.3216	0.3237	C.3207	0.3191	0.3177	C.3168
0.3163	C.3158	0.3157	0.3155	C.3125	0.3139	0.3116	0.3103
0.3086	C.3022	0.2988	0.2954	C.2956	0.2931	0.2919	0.2937
0.2954	C.2955	0.2940	0.2923	C.2928	0.2930	0.2927	0.2904
0.2868	C.2786	0.2713	0.2693	C.2684	0.2673	0.2662	0.2663
0.2644	C.2679	0.2731	0.2775	C.2764	0.2737	0.2798	C.2856

ARRAY OF PRESSURE COEFFICIENTS

-- FILE - W54516

0.3107	C.3140	0.3189	0.3243	C.3272	0.3294	0.3344	0.3351
0.3411	C.3416	0.3452	0.3446	C.3453	C.3425	0.3424	C.3461
0.3441	C.3426	0.3442	0.3475	C.3508	0.3489	0.3497	0.3510
0.3525	C.3553	0.3532	0.3568	C.3555	0.3540	0.3553	C.3505
0.3507	C.3498	0.3508	C.3500	C.3420	0.3414	0.3431	C.3439
0.3402	C.3367	0.3350	0.3355	C.3373	0.3330	0.3343	0.3373
0.3417	C.3433	0.3431	0.3417	C.3419	0.3423	0.3418	0.3457
0.3459	C.3440	0.3406	0.3365	C.3353	C.3338	0.3343	0.3349
0.3365	C.3380	0.3366	0.3337	C.3297	0.3283	0.3308	0.3326
0.3316	C.3321	0.3327	0.3329	C.3336	0.3376	0.3420	0.3388
0.3417	C.3419	0.3423	0.3446	C.3447	0.3423	0.3399	0.3397
0.3372	C.3362	0.3360	0.3295	C.3256	0.3216	0.3177	C.3110
0.3121	C.3071	0.2992	0.2946	C.2939	0.2942	0.2922	C.2901
0.2912	C.2937	0.2950	0.3015	C.3030	0.3031	0.3023	C.3013
0.2965	C.2992	0.2948	0.2943	C.2937	0.2932	0.2924	0.2924
0.2962	C.2998	0.3032	0.3014	C.3058	0.3059	0.3051	C.3086
0.3132	C.3181	0.3235	0.3298	C.3299	0.3357	0.3399	0.3424
0.3387	C.3423	0.3427	0.3464	C.3503	0.3537	0.3516	C.3491
0.3476	C.3479	0.3493	0.3507	C.3520	0.3544	0.3504	0.3519
0.3549	C.3571	0.3561	0.3560	C.3560	0.3556	0.3550	0.3524
0.3549	C.3507	0.3469	C.3485	C.3474	0.3445	0.3433	0.3433
0.3398	C.3420	0.3384	0.3393	C.3383	0.3374	0.3408	0.3382
0.3352	C.3334	0.3333	0.3366	C.3346	0.3363	0.3337	0.3360
0.3367	C.3371	0.3370	0.3399	C.3375	0.3381	0.3371	0.3365
0.3361	C.3358	0.3348	0.3321	C.3345	0.3339	0.3341	0.3290
0.3306	C.3328	0.3353	0.3378	C.3396	C.3385	0.3362	C.3363
0.3404	C.3390	0.3377	C.3400	C.3389	0.3370	0.3378	0.3321
0.3327	C.3327	0.3312	0.3293	C.3287	0.3244	0.3254	C.3202
0.3148	C.3091	0.2984	C.2929	C.2926	0.2914	0.2907	0.2944
0.2968	C.2993	0.3019	0.2983	C.2997	0.3012	0.3026	0.3027
0.3009	C.2987	0.2965	0.2946	C.2971	0.2991	0.3012	C.3035
0.3002	C.3018	0.3090	0.3103	C.3103	0.3095	0.3116	0.3150

LIST OF REFERENCES

1. Shreeve, R. P., and others, Determination of Transonic Compressor Flow Field by Synchronized Sampling of Stationary Fast Response Transducers, paper presented at Symposium on Non-Steady Fluid Dynamics, ASME 1978 Winter Annual Meeting, San Francisco, California, December 1978.
2. Demo, W. J., Jr., Cascade Wind Tunnel for Transonic Compressor Blading Studies, M.S.A.E. Thesis, Naval Postgraduate School, Monterey, California, June 1978.
3. Volland, K. F., Jr., Transonic Cascade Wind Tunnel Modification and Initial Tests, M.S.A.E. Thesis, Naval Postgraduate School, Monterey, California, June 1980.
4. Eidelman, Shmuel, and others, Application of the Godunov Method and Higher Order Extension of the Godunov Method to Cascade Flow Modeling, paper presented at AIAA 6th Computational Fluid Dynamics Conference, AIAA-83-1941-CP, Danvers, Massachusetts, July 1983.
5. Simmons, J. M., and Shreeve, R. P., Data Acquisition and Analysis Techniques for Measurement of Unsteady Wall Pressures in a Transonic Compressor, NPS Report NPS-67sf77071, July 1977.
6. Geopfarth, R. N., Development of a Devise for the Incorporation of Multiple Scanivalves into a Computer Controlled Data System, M.S.A.E. Thesis, Naval Postgraduate School, Monterey, California, March 1979.
7. Paige, G. C., Measurement of Case Wall Pressure Signatures in a Transonic Compressor Using Real-Time Digital Instrumentation, M.S.A.E. Thesis, Naval Postgraduate School, Monterey, California, June 1976.
8. Hewlett-Packard Operating and Service Manual, Model 3455A Digital Voltmeter, HP03455-90002, June 1976.
9. Hewlett-Packard Operating and Service Manual, Analog-to-Digital Convertor, 5610A, HP05610-91999, January 1972.

10. West J. C., Digital Programmable Timing Device for Fast Response Instrumentation in Rotating Machines, M.S.A.E. Thesis, Naval Postgraduate School, Monterey, California, June 1976.
11. McCarville, P. A., Hardware and Software Improvements to a Paced Data Acquisition System for Turbomachines, M.S.A.E. Thesis, Naval Postgraduate School, Monterey, California, June 1981.
12. Hewlett-Packard Reference Manual, HP-21MX Computer Series HP02108-900002, June 1976.
13. Hewlett-Packard Operating and Service Manual, High Speed Acquisition Subsystem 2311A, HP02311-90003, March 1970.
14. Hewlett-Packard User's Manual, 7906 Disc Drive, HP07906-90901, 1978.
15. Cornell, D. W., Procedure for Synchronized Acquisition of Wall Pressures in a Transonic Compressor Using the HP-21MX, NPS Technical Note 83-01, September 1983.
16. Hewlett-Packard Reference Manual, RTE-IVB Programmer's Reference Manual, HP-92068-90004, October 1980.
17. IMSL Reference Manual, IMSL Library, International Mathematical & Statistical Libraries, Inc., 1982.
18. ISSCO Reference Manual, DISSPLA Pocket Guide, Integrated Software Systems Corporation, San Diego, California, October 1981.
19. Zebner, H., Transonic Compressor: Program System TXCO0 for Data Acquisition and On-Line Reduction, Contractor Report No. NPS67-80-02CR, October 1980.
20. Shreeve, R. P., Calibration of Flow Nozzles Using Traversing Pitot-Static Probes, NPS Technical Note 57sf73071A, July 1973.
21. McCracken, D. D., and Dorn, W. S., Numerical Methods and FORTRAN Programming, New York: Wiley & Sons, 1964, pp. 262-266.
22. Hewlett-Packard Reference Manual, DOS/RTE Relocatable Library, HP 24998-90001, July 1980 (Update 5 October 1981).
23. Hewlett-Packard User's Manual, HP-IB in HP1000 Computer Systems, HP 59310-90064, July 1980.

24. Holman, J. P., Experimental Methods for Engineers, New York: McGraw-Hill, 1978.
25. Hewlett-Packard User's Manual, HP2840A Graphics Plotting Software, HP 92840-90001, July 1980.
26. Arnold, M. J., and Fjelde, J. A., Preliminary Calibration of a Cascade Wind Tunnel, AE 3815 Laboratory Report, Department of Aeronautics, Naval Postgraduate School, Monterey, California, 23 September 1978.

INITIAL DISTRIBUTION LIST

	No. Copies
1. Defense Technical Information Center Cameron Station Alexandria, Virginia 22314	2
2. Library, Code 0142 Naval Postgraduate School Monterey, California 93943	2
3. Department Chairman, Code 67 Department of Aeronautics Naval Postgraduate School Monterey, California 93943	1
4. Director Turbopropulsion Laboratory Code 67sf Naval Postgraduate School Monterey, California 93943	10
5. LCDR David W. Cornell, USN 1541 Canna Ct. Mountain View, California 94040	2
6. Mr. George Derderian Naval Air System Command Code AIR-310E Department of the Navy Washington, D.C. 20360	1
7. Commander (Attn. V. Lubosky) Naval Air Propulsion Center Trenton, New Jersey 08628	1

205506

Thesis
C75496 Cornell
c.1

Experimental deter-
mination of the rela-
tive flow at the tip of
a transonic axial com-
pressor rotor.

205506

Thesis
C75496 Cornell
c.1

Experimental deter-
mination of the rela-
tive flow at the tip of
a transonic axial com-
pressor rotor.



thesC75496

Experimental determination of the relati



3 2768 002 09173 8

DUDLEY KNOX LIBRARY